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INTRODUCTION

This handbook provides information necessary to repair Radar Set AN/APN-105 in the field if replacement subassemblies are available as spares. Owing to the complexity of the equipment, the large number of electronic parts and the difficulties involved in servicing subassemblies (necessity for moisture-proofing of printed circuits and associated parts), field-maintenance is limited to the replacement of defective subassemblies and a few other conveniently replaceable items (fuses, klystrons, holder-mounted crystal diodes and some items on terminal boards).

Troubleshooting procedures first identify the defective component (major unit) and then localize the trouble to a specific subassembly of that component. Troubleshooting procedures in the system check-out and the maintenance sections are designed to isolate defects by means of signal tracing. Skillful troubleshooting requires a firm grasp of the theory of operation (Section IV) and component maintenance (Sections VII through XIV). The troubleshooting procedures in Section VI check out the system and help isolate the defective component. Troubleshooting procedures in the appropriate component section then aid in finding the defective subassembly.

Significant test points are called out in the test procedures of Sections VI through XIV. These test points are identified in the appropriate block or intercabling diagram; the physical location of the test point may be ascertained from the subassembly location drawing of each component. All test points used in field maintenance are external to a subassembly, as trouble need be localized to only one subassembly. An explanation of the use of test points appears at the beginning of Section IV.

Each component (major unit) is an assembly. Circuit groupings in physical units within a component are subassemblies.

Diagrams of each component are located in the appropriate component maintenance section. Diagrams of system signal flow, power distribution and system intercabling are contained in Section VI. Diagrams of each subassembly are supplied in block form, since internal circuitry need not be investigated for field maintenance. The detailed theory of operation is contained in the component maintenance section to which it pertains.

Diagram symbol charts are located in Section VI.

A glossary of technical terms contained in each section is provided at the beginning of that section if required.

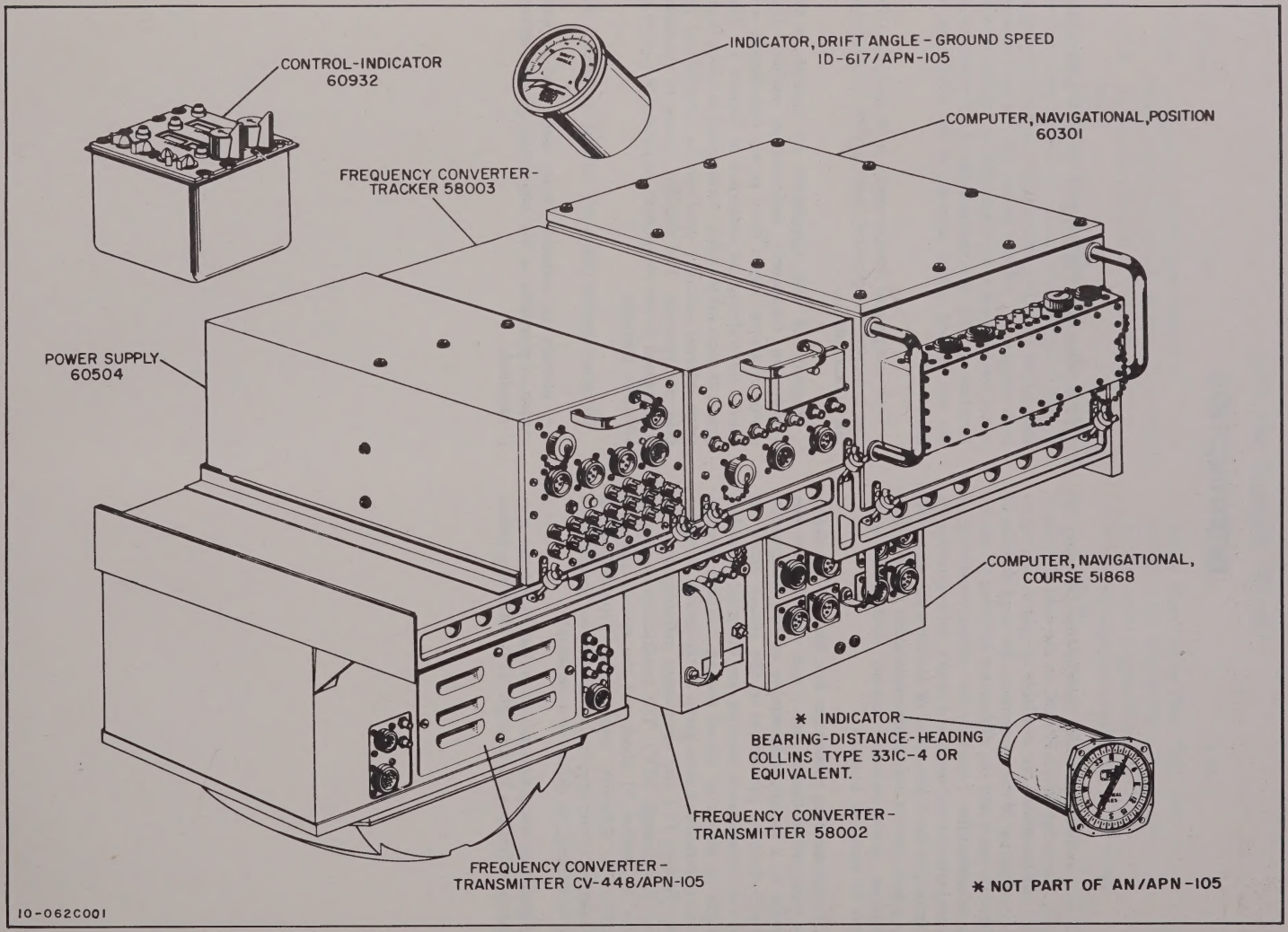


Figure 1–1. Radar Set AN/APN-105

SECTION I

DESCRIPTION AND LEADING PARTICULARS

1–1. GENERAL DESCRIPTION OF SYSTEM PERFORMANCE.

1–2. GENERAL. This handbook contains information and instructions for field maintenance of Radar Set AN/APN-105, and comprises service instructions for Radar Set AN/APN-105. Radar Set AN/APN-105 (see figure 1–1) is an airborne electronic aid to navigation utilizing the doppler effect. This radar set transmits signals to the ground to provide continuous displays for pilot guidance, as listed in table 1–1.

1–3. The displays are allocated among the indicators shown in figure 1–2.

Table 1–1. Displays and Definitions

Control-Indicator 60932	
Present position latitude	The latitude coordinate of the aircraft's present position is continuously displayed in the LATITUDE window of the Control Indicator when the Coordinate Display Switch is set to PRES. (This is the usual display.)
Present position longitude	The longitude coordinate of the aircraft's present position is continuously displayed in the LONGITUDE window of the Control Indicator when the Coordinate Display Switch is set to PRES. (This is the usual display.)

Table 1–1. Displays and Definitions (Cont)

Destination A latitude	The latitude coordinate of destination A is displayed in the LATITUDE window of the Control Indicator when the Coordinate Display Switch is set to DEST A.
Destination A longitude	The longitude coordinate of destination A is displayed in the LONGITUDE window of the Control Indicator when the Coordinate Display Switch is set to DEST A.
Destination B latitude	The latitude coordinate of destination B is displayed in the LATITUDE window of the Control Indicator when the Coordinate Display Switch is set to DEST B.
Destination B longitude	The longitude coordinate of destination B is displayed in the LONGITUDE window of the Control Indicator when the Coordinate Display Switch is set to DEST B.
Note Visible display of a coordinate is a prerequisite to slewing of that coordinate by means of a slew switch. (Refer to paragraph 1–30.)	
Memory	The MEMORY lamp on the Control Indicator panel illuminates when the system is operating in the memory mode.
Indicator, Drift Angle-Ground Speed ID-617/APN-105 (Ground Speed Indicator)	
Ground speed	Ground speed in knots is continuously displayed in the GROUND SPEED window of the Ground Speed Indicator.
Drift angle	The drift angle, which is the difference in degrees between the aircraft heading angle (pointing) and the aircraft track angle (going), is displayed on the DRIFT ANGLE scale of the Ground Speed Indicator in degrees right or left. The track angle with respect to the heading angle reference determines whether the drift is right or left.
INDICATOR, BEARING-DISTANCE-HEADING ID-416/ARN (Course Indicator) or COLLINS RADIO TYPE 331C-4A	
Course Angle	The course angle, computed within the analog section of Computer, Navigational 51868 (Course Computer) is indicated by a pointer. The angle designated by the course angle pointer is the correct angle with respect to north that the aircraft should fly to reach the pre-selected destination. The course angle pointer refers to degree markings on a rotating card, positioned by the track angle. When the aircraft track angle changes, the rotating card and the course pointer turn simultaneously, maintaining the same course angle indication.

Table 1–1. Displays and Definitions (Cont)

Ground Track	The ground track angle is indicated at the top of the rotating card in the Course Indicator. The ground track angle is the direction with respect to north that the aircraft is actually going. The correct flight plan is followed by flying the aircraft at a ground track angle identical to the course angle. In this case the course pointer will be aligned with the top of the Course Indicator.
Distance-to-Destination	The distance in nautical miles from the aircraft present position to the preselected destination is computed within the Course Computer and displayed on the counter of the Course Indicator.

1–4. Radar Set AN/APN-105 provides outputs for use with other electronic equipment. When operated with an autopilot, for example, the two systems constitute an automatic navigational system. A list of all Radar Set AN/APN-105 outputs is contained in Section V, Description of System Tie-in of Equipment and Accessories, is shown in figure 5–1.

1–5. SYSTEM CAPABILITIES AND LIMITATIONS. The most severe combination of operating conditions for this navigator is a very calm sea (less than Beaufort 1) at the maximum operating altitude. The calm sea will reflect little energy in the direction of the aircraft, and the extreme altitude will also place demands on the sensitivity of the equipment. Further, any roll and pitch variance under these conditions serve to increase the demand on system performance. Nevertheless, this system incorporates adequate facilities for operation during combinations of all these circumstances.

1–6. Any extended period of violent maneuver can limit system accuracy. This is true because the stabilizing limits of the system are $\pm 20°$ of roll and pitch. When the aircraft roll or pitch exceeds these limits computation accuracy is reduced. Should an extreme attitude be attained (greater than 27-1/2° pitch or roll) a limit switch will operate and place the system in the wind memory mode. In this mode, the system does not utilize the ground-reflected data but will continue to compute present position by using the airspeed input from the Air Data Computer and the wind velocity output from the wind memory circuits. The navigator will again compute present position from ground-reflected data when the attitude of the aircraft re-enters the range of stabilizing limits and doppler signal is again available.

1–7. The Course Computer can solve course angle and distance-to-destination for all destinations 2000 miles or less from the present position coordinates. An alternate set of destination coordinates may be set in the Course Computer. When the aircraft is within 2000 miles of the alternate destination, it may be switched in by the Course Switch, and the Course Computer then solves course angle and distance-to-destination for the alternate set of destination coordinates. In addition, either set of destination coordinates may be changed during flight and, as long as the destination chosen for display and computation is less than 2000 miles from the present position, the Course Computer will automatically compute course angle and distance to the new destination. The flexibility of this procedure follows because the present position coordinates are not affected by alterations of destination coordinates.

1–8. This system is capable of navigation using either the normal grid pattern of the earth or a transverse grid pattern. The normal mode of operation is used for any flight contained below 75° latitude, and the transverse or polar mode is used for any flight beyond 75° latitude. This is necessary because of the weak horizontal component of the earth's magnetic field above this latitude and because the heavy concentration of longitude lines make computation difficult. The transverse grid pattern avoids these difficulties: first, by using a free-gyro heading reference instead of magnetic slaving; and second, by transferring the concentration of longitude lines to a new polar reference located on the equator at the Greenwich Meridian.

1–9. Additional system capabilities and limitations are listed in table 1–2.

Table 1–2. System Capabilities and Limitations

Operational Limits	Altitude	0 to 70,000 feet
	Drift angle	±30°
	Geographical range	±75° latitude for both normal and transverse grid coordinates. By proper choice of grid systems, flights can be planned over any part of the globe. (See paragraph 1–8.) The destination must be reset every 2000 miles. (See paragraph 1–7.)
	Ground Speed	0 to 1500 knots
	Stabilization	±20° pitch and roll (±27-1/2° pitch and roll with reduced accuracy)
	Velocity (horizontal)	1500 knots (maximum)
	Velocity (vertical)	±50,000 feet per minute
Performance Accuracy	Course angle (short range)	$\sqrt{(\text{Arc Tan}\frac{2}{\text{dist to go}})^2 + (14\text{ min})^2}$
	Course angle (long range)	$\sqrt{(\text{Arc Tan}\frac{16}{\text{dist to go}})^2 + (14\text{ min})^2}$
	Distance-to-go (short range)	±4 miles
	Distance-to-go (long range)	±20 miles
	Drift angle	±1.0° (as read on Ground Speed Indicator)
	Ground Track*	±1.3° (as read on BDHI)
	Ground Speed	±2 knots or ±2 percent of total ground speed, whichever is greater.
	Present Position Latitude*	±(1 min +0.3% of north-south distance traveled)
	Present Position Longitude*	±(1 min +0.3% of east-west distance traveled × secant lat)

*The present position and ground track tolerances require a perfect heading input from the Compass System. An inaccurate heading input will result in a wider tolerance for these outputs. The additional tolerance (in per cent) is equal to the tangent of the heading error × 100 and is added to the system tolerance of 0.3%. For example, assume an input heading error of 1°. The tangent of 1° × 100 = 1.7. Therefore the corrected system tolerance is:

$$0.3\% + 1.7\% = 2.0\%$$

This 2.0% system tolerance would be substituted for the 0.3% in the present position tolerances given above. The across course error (distance to the left or right of the proper destination) caused by the 1.7% heading error for a 100 mile flight, would be 1.7 miles.

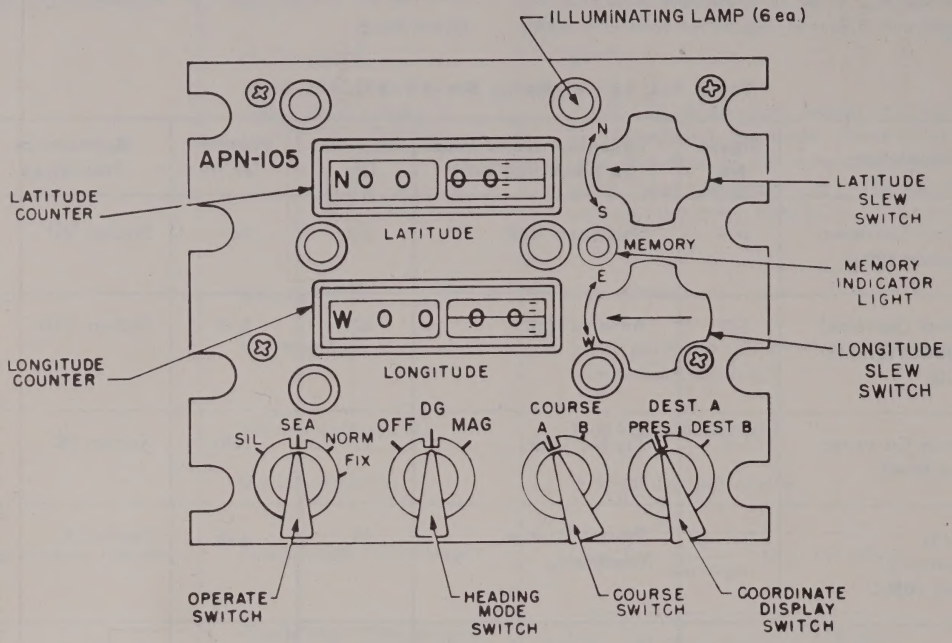
1–10. DESCRIPTION OF RADAR SET AN/APN-105 UNITS.

1–11. GENERAL. A list of Radar Set AN/APN-105 units is given in table 1–3. Figure 1–1 shows the entire system mounted on the Aircraft Mounting Rack. Figure 1–3 is a simplified block diagram of Radar Set AN/APN-105. Figures 1–4 through 1–11 are illustrations of all system units.

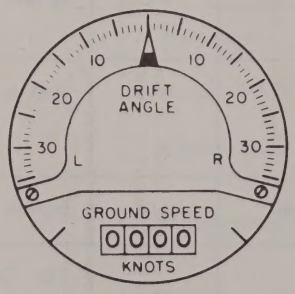
Table 1–3. List of Radar Set AN/APN-105 Units

Nomenclature	Figure No.	Colloquial Name Used in Instruction Book	Max Wt (lb)	Volume* (cu ft)	Maintenance Procedures
Frequency Converter-Transmitter 58002	1–4	Modulator Unit	11	0.42	Section VII
Frequency Converter-Transmitter CV-448/APN-105	1–5	Antenna Unit	42	3.18	Section VIII
Frequency Converter-Tracker 58003	1–6	Tracker Unit	31	1.00	Section IX
Computer Navigational, Position 60301	1–7	Present Position Computer	65	2.16	Section X
Computer, Navigational, Course 51868	1–8	Course Computer	42	0.77	Section XI
Control-Indicator 60932	1–9	Control Indicator	4.5	0.11	Section XII
Indicator, Drift Angle-Ground Speed ID-617/APN-105	1–10	Ground Speed Indicator	1.5	0.03	Section XIII
Power Supply 60504	1–11	Power Supply	40	1.06	Section XIV
Indicator, Bearing-Distance-Heading ID-416/ARN or Collins Radio type 331C-4A or equivalent		Course Indicator			The Course Indicator is used but not supplied with Radar Set AN/APN-105

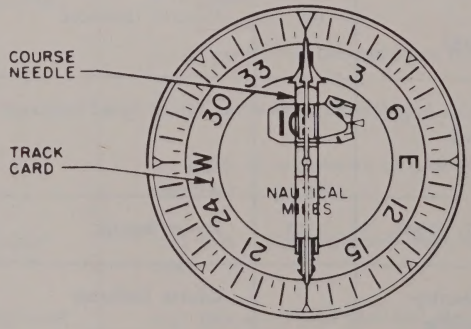
*Unit volumes were computed using the extreme outside dimensions, including handles, connectors, controls, and mounting brackets.



CONTROL-INDICATOR
60932



INDICATOR,
DRIFT ANGLE-GROUND SPEED
ID-617/APN-105
(GROUND SPEED INDICATOR)



INDICATOR,
BEARING-DISTANCE-HEADING
331C-4A
(COURSE INDICATOR) *

* NOT PART OF RADAR SET AN/APN-105

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Figure 1—2. Radar Set AN/APN-105 Indicators and Displays

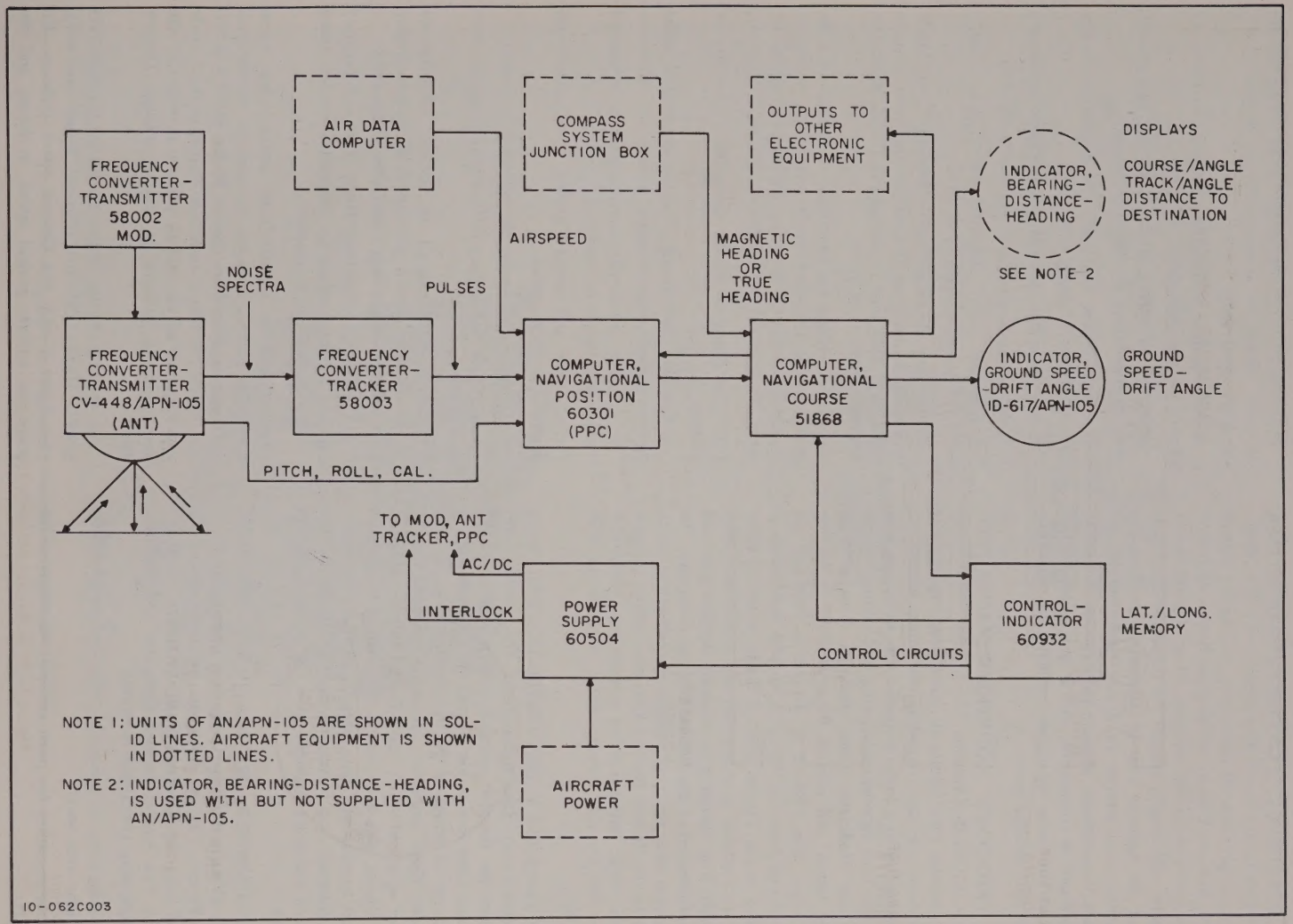


Figure 1–3. Radar Set AN/APN-105, Simplified Block Diagram

1–12. FREQUENCY CONVERTER-TRANSMITTER 58002 (Modulator Unit). (See figure 1–4.) The Modulator Unit generates all modulating and mixing signals for the Antenna Unit by utilizing the harmonics from a single crystal-controlled oscillator. Most of these signals are gated and thereby control the transmit-receive cycling of the Antenna Unit by alternately enabling the transmitter and receiver at a rate controlled by the altitude. A barometric pressure switch senses changes in altitude and in conjunction with a gate generator, determines the pulse repetition frequency of the transmitter and receiver gates.

1–13. FREQUENCY CONVERTER-TRANSMITTER CV-448/APN-105 (Antenna Unit). (See figure 1–5.) The Antenna Unit fulfills all microwave requirements of transmitting and receiving, including heterodyne i-f conversion to a lower frequency for an output. The Antenna Unit receives modulating and mixing signals from the Modulator Unit, transmits three 9799-mc pulsed beams, and receives three 9799-mc ± doppler shift echos. The 9799-mc ± doppler is amplified and heterodyned down to 500 kc ± doppler shift which is supplied to the Tracker Unit. Included in the Antenna Unit are a vertical gyro assembly and a calibration relay assembly. The vertical gyro assembly supplies pitch and roll information to the Present Position Computer. The calibration relay assembly controls the calibration multipliers in the Present Position Computer which compensate for slight variation in the antenna beam depression angle and for the skewing effect of water in SEA operation.

1–14. FREQUENCY CONVERTER-TRACKER 58003 (Tracker Unit). (See figure 1–6.) The Tracker Unit converts the doppler spectrum output signals of the Antenna Unit into single frequencies corresponding to the center of power of the doppler spectrum for each channel. These single frequencies are combined according to equations which solve for aircraft velocities in the forward, side and vertical directions as referred to aircraft coordinates. These three frequency combinations are converted into pulses and supplied to the Present Position Computer together with the required polarity signals.

1–15. COMPUTER, NAVIGATIONAL, POSITION 60301 (Present Position Computer). (See figure 1–7.) The Present Position Computer reference pulses received from the Tracker Unit to the earth's coordinate system. The Present Position Computer also performs the following specialized functions:

a. count-down of incoming pulses and compensation for flight over water

b. compensation for pitch and roll variations of the aircraft

c. provision of computed ground speed during periods of radar silence or missing doppler return signals, using air speed data

d. compensation of longitude stepping according to present position latitude

e. storage of pulses while correcting the present position coordinates by means of a fix.

1–16. COMPUTER GROUP. The Computer Group consists of the following units:

a. Computer, Navigational 51868 (Course Computer)

b. Control-Indicator 60932 (Control Indicator)

c. Indicator, Drift Angle-Ground Speed ID-617/APN-105 (Ground Speed Indicator)

d. Indicator, Bearing-Distance-Heading ID-416/ARN or Collins Radio type 331C-4a or equivalent (Course Indicator). This unit is not supplied with Radar Set AN/APN-105.

e. Also included are seven servo amplifiers and six resolver drive amplifiers which functionally belong to the Computer Group, but physically are located in Computer, Navigational 60301 (Present Position Computer).

1–17. The functions of the Computer Group are as follows:

a. Compute and display distance in nautical miles between present position and a preselected destination.

b. Compute and display course angle to a preselected destination relative to north.

c. Compute and display ground track in azimuth degrees relative to north.

d. Compute and display ground speed in knots.

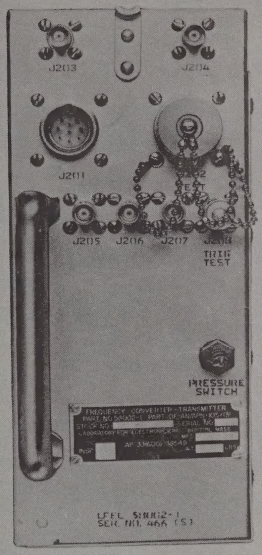
e. Compute and display drift angle in degrees from true heading.

f. Continuous display of the latitude and longitude of the aircraft's present position or permanent display of either one of the two preselected destinations.

g. Computer, Navigational 51868 (Course Computer) compensates the heading for magnetic variation when using a magnetic-type compass.

1–18. CONTROL INDICATOR 60932. (See figure 1–9.) The Control Indicator contains all the switches and controls needed to operate Radar Set AN/APN-105. It also provides a continuous display of the latitude and longitude of the present position or either of the destinations as selected by the Coordinate Display Switch.

1–19. INDICATOR, DRIFT ANGLE-GROUND SPEED ID-617/APN-105 (Ground Speed Indicator). (See figure 1–10.) The Ground Speed Indicator displays the aircraft ground speed, in knots, and the



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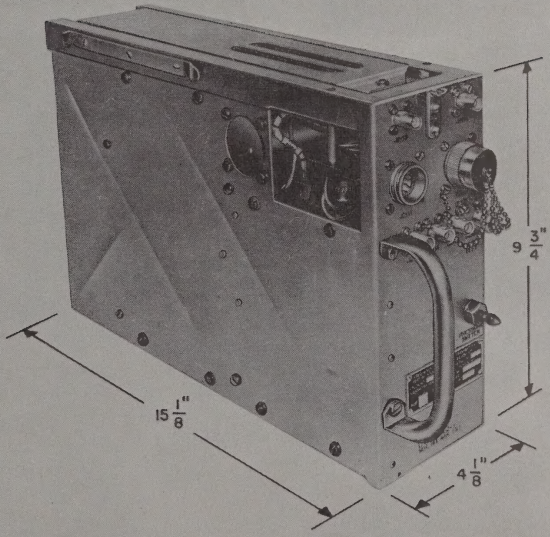

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Figure 1–4. Frequency Converter-Transmitter 58002

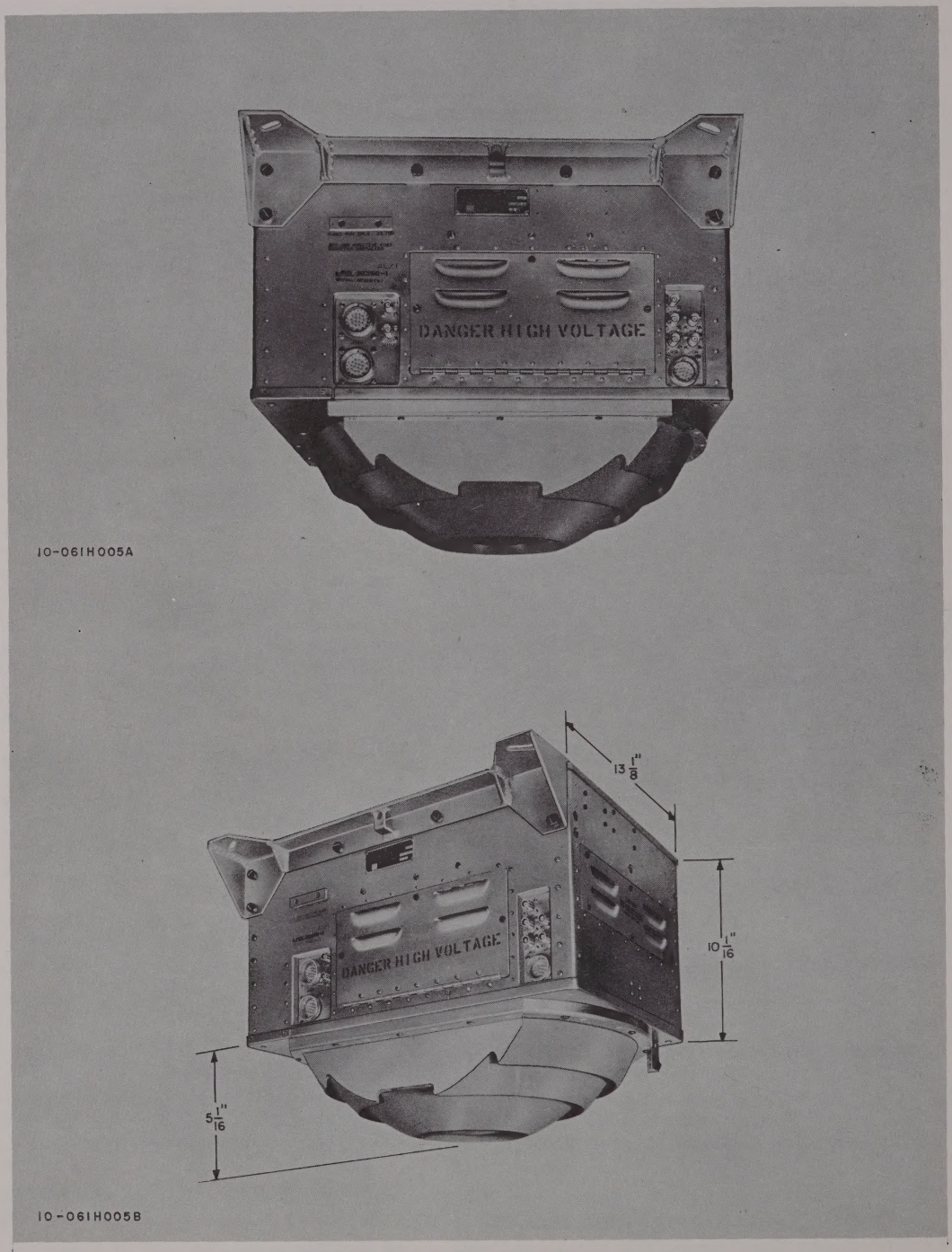
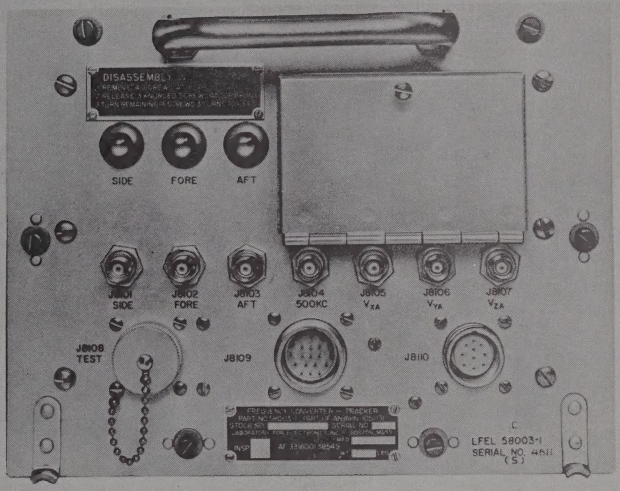


Figure 1–5. Frequency Converter-Transmitter CV-448/APN-105



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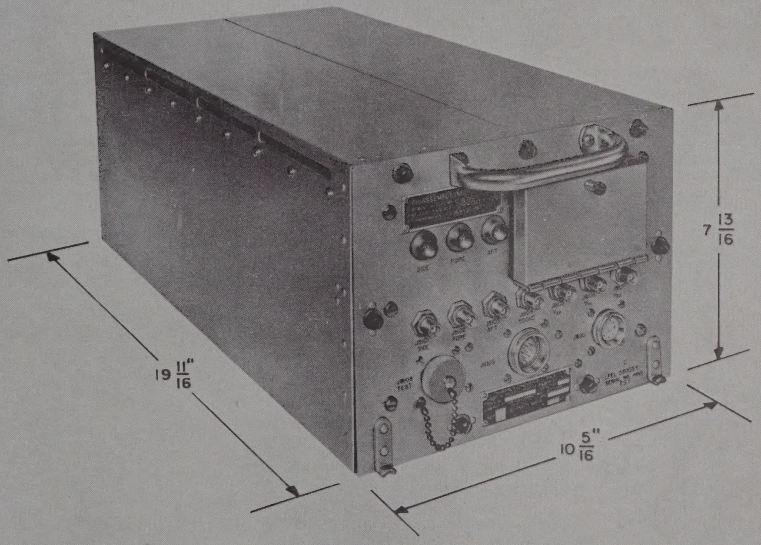

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Figure 1–6. Frequency Converter-Tracker 58003

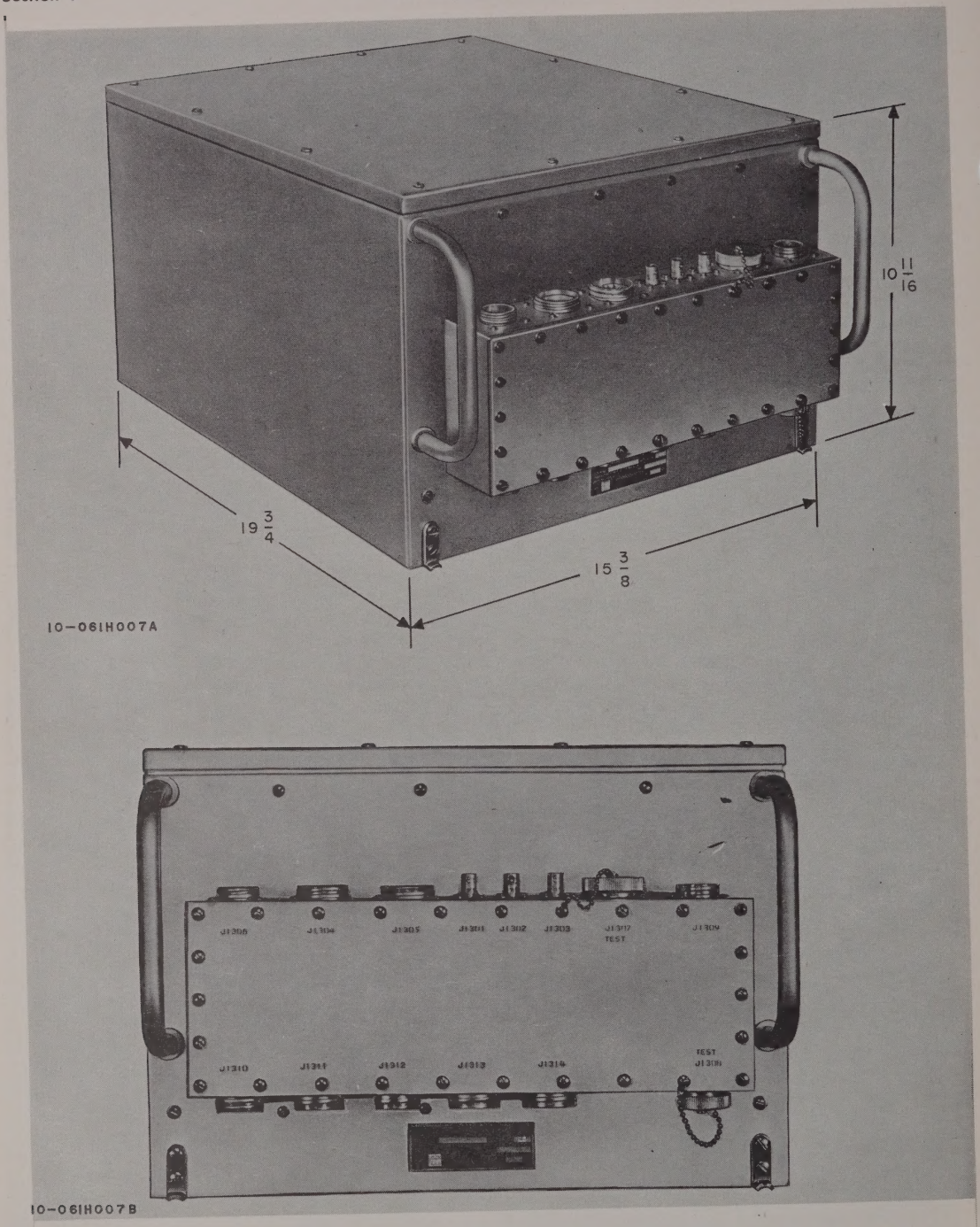

Figure 1–7. Computer, Navigational, Position 60301

Figure 1-8. Computer, Navigational, Course 51868

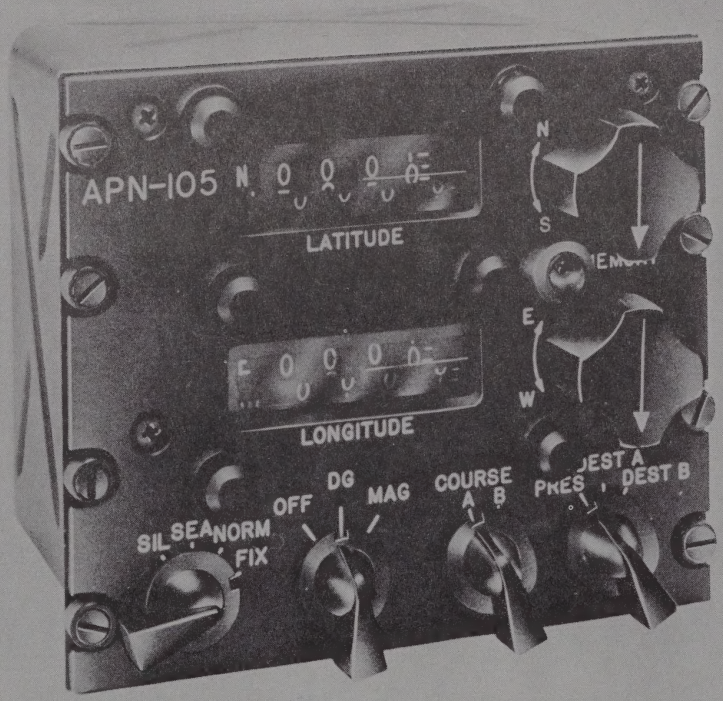

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Figure 1–9. Control Indicator 60932

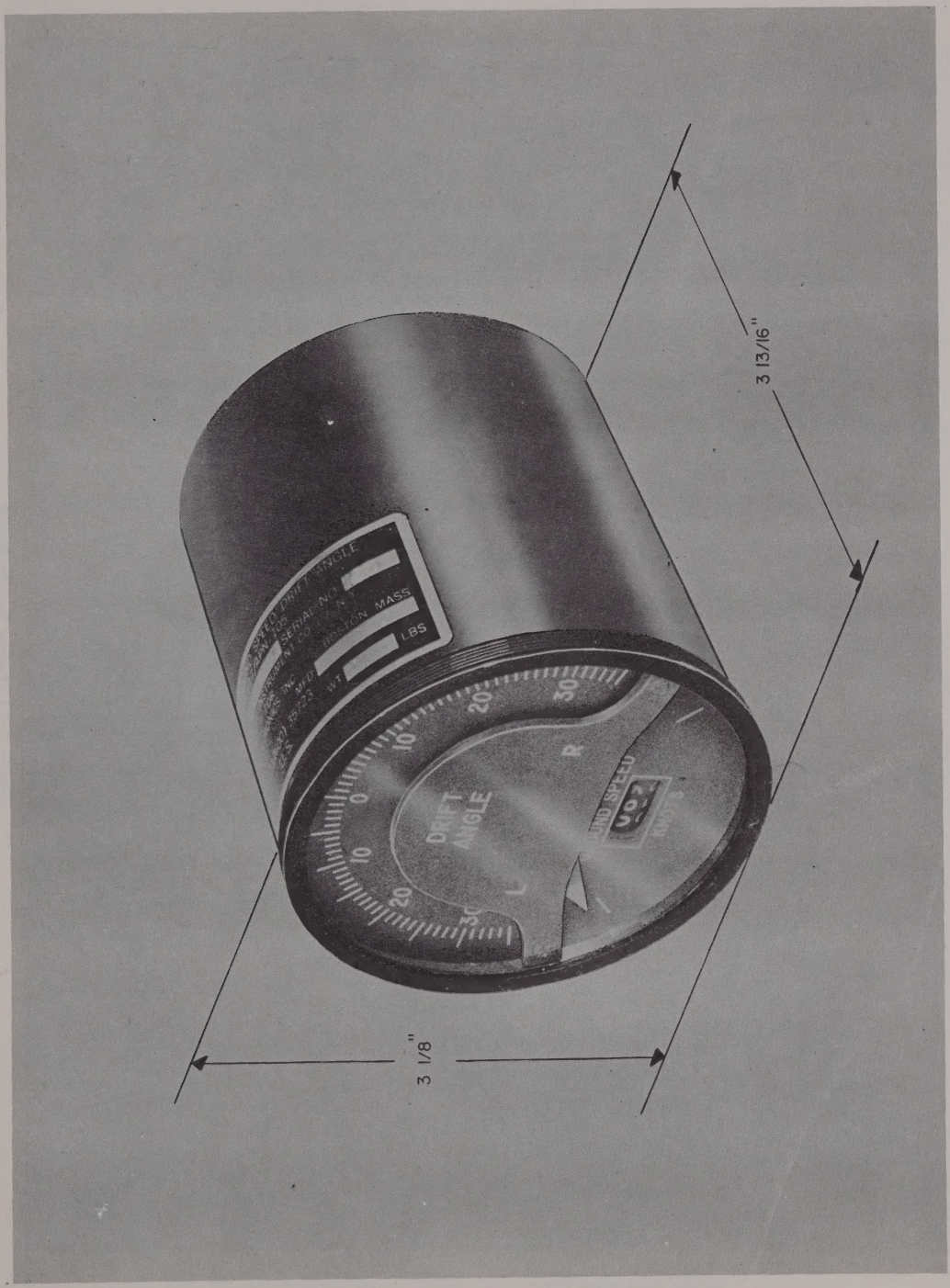

Figure 1–10. Indicator, Drift Angle-Ground Speed ID-617/APN-105

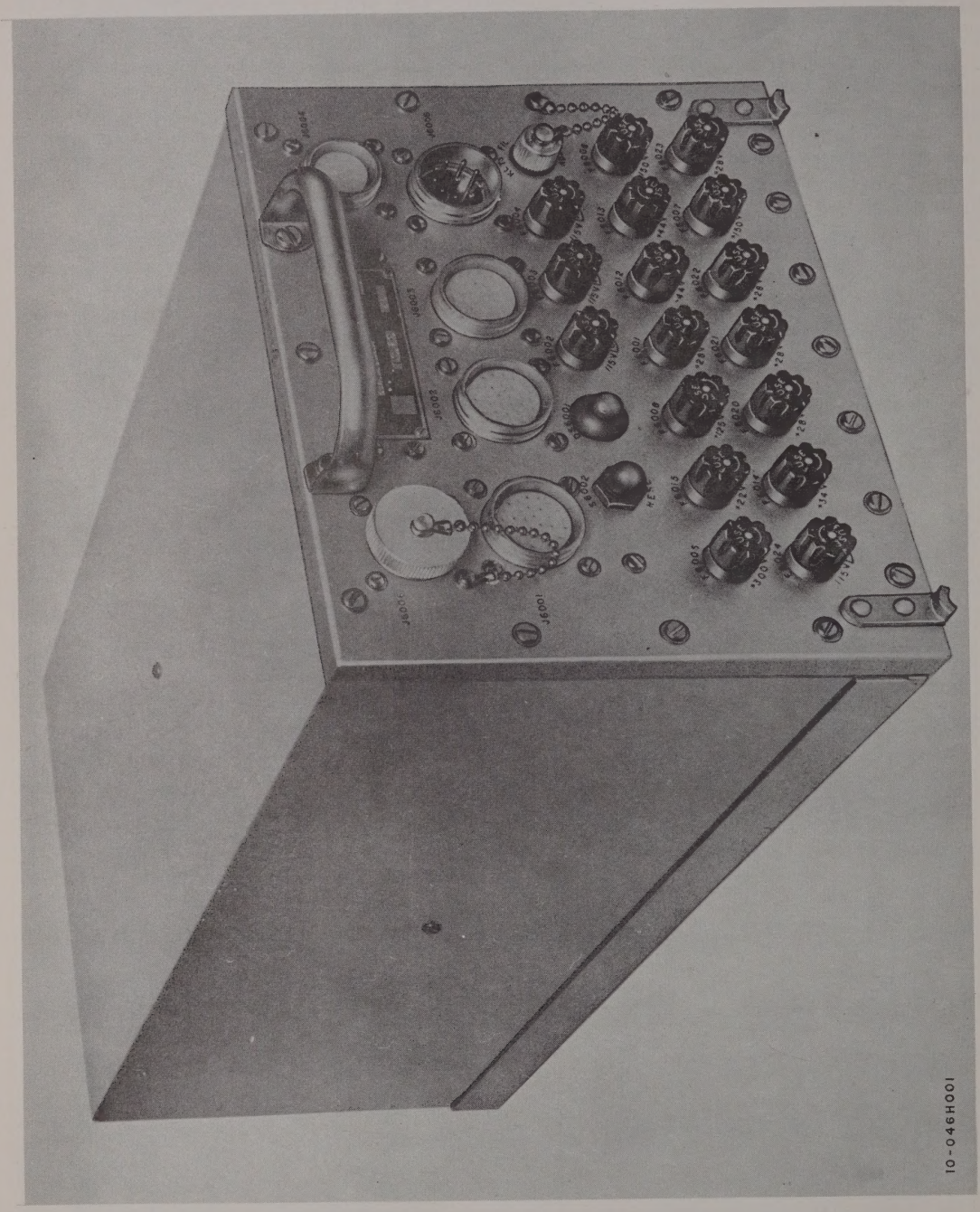

Figure 1-11. Power Supply 60504

aircraft drift angle in degrees left or right of aircraft heading.

1–20. POWER SUPPLY 60504 (Power Supply). (See figure 1–11.) The Power Supply provides the d-c and a-c voltages required to operate Radar Set AN/APN-105. The d-c outputs of one high-voltage section and the four intermediate-voltage sections are individually and automatically self-regulated. In addition, the Power Supply provides safety features such as an interlock circuit and an improper-voltage protection circuit with visual alarm.

1–21. POWER AND SIGNAL INPUTS REQUIRED.

1–22. POWER. The power requirements are listed below.

a. 108 to 121V a-c, 3-phase, 380 to 420 cps:
   0°, 250w, 3.0 ± 0.5 amp, PF = 0.50 lag
   +120°, 300w, 4.0 ± 0.5 amp, PF = 0.55 lag
   −120°, 290w, 3.0 ± 0.5 amp, PF = 0.60 lag

b. +25 to +29V d-c = 280 w, 10.5 ± 0.5 amp

c. 24.5 to 27.5V a-c, 380 to 420 cps, single-phase, (0°), 44 va, PF = 0.80 lag

1–23. HEADING REFERENCE. An aircraft heading reference is essential for the operation of Radar Set AN/APN-105. A three-wire synchro-signal is required from either a magnetic-heading reference or free-gyro heading reference. If a magnetic heading reference is used, Radar Set AN/APN-105 compensates automatically for magnetic variation. If a free-gyro heading reference is used, the gyro must be oriented to the transverse pole by slewing the gyro.

1–24. AIR SPEED SIGNALS. A d-c voltage representing true air speed is required for the operation of the wind memory circuits in the Present Position Computer. This voltage is provided by the aircraft's Air Data Computer.

1–25. SYSTEM TECHNICAL CHARACTERISTICS.

1–26. A summary of Radar Set AN/APN-105 technical characteristics is given in table 1–4.

Table 1–4. Summary of Radar Set AN/APN-105 Technical Characteristics

Antenna beam depression angle	70° nominal
Antenna size	19-11/32″ x 13-1/8″
Doppler shift	1 cps = 0.6-inch vector of aircraft motion along beam axis
Duty cycle	50 per cent
I-f amplifier gain	110 db
I-f amplifier bandwidth (over-all)	40 kc
Power consumption	108 to 121 V, 3-phase, 380-420 CPS 1,242 va, 25-29 V dc, 9.2 amp, 250 w.
Pulse repetition frequency	proportional to barometric pressure
System bandwidth (not tracking)	24 kc
System bandwidth (tracking)	800 cps
System signal-to-noise ratio	2/3 minimum
Transmitted frequency	9799 ±1 mc
Transmitted power output (per beam)	1/3 watt peak power

Table 1–4. Summary of Radar Set AN/APN-105 Technical Characteristics (Cont)

Total transmitted power output	28.5 dbm, minimum
Air speed input sensitivity	14.7 mv/knot (voltage inversely related to air speed)
Total volume (including projecting handles, connectors and controls)	11.23 cubic feet
Total weight (without cables, mountings, etc.)	244 lb. maximum

WARNING

High voltages which are dangerous to operating and maintenance personnel are used in this equipment.

1–27. OPERATOR CONTROLS AND FUNCTIONS.

1–28. GENERAL. All operator controls are located on the Control Indicator. The location of these controls are shown in figure 1–2; their functions are listed in table 1–5.

Table 1–5. Functions of Operator Controls

Control	Function
Course Switch (COURSE A-COURSE B)	Selects one of the two preset destinations for course and distance computation.
Coordinate Display Switch (PRES-DEST A-DEST B)	Selects coordinates for counter display and makes these coordinates available for slewing.
Operate Switch (SIL-SEA-NORM-FIX)	Selects mode of operation (SEA: operation over water; NORM: operation over land; SIL: operation on wind memory with radar transmitter off; FIX: temporary storage of computed distance to permit correction of present position information).
Latitude Slew Switch	Slews latitude coordinate of position displayed on latitude counter (present position, destination A or destination B, as selected by Coordinate Display switch).
Longitude Slew Switch	Slews longitude coordinate of position displayed on longitude counter.
Mode Switch (OFF-DG-MAG)	Turns equipment on or off, and selects desired heading reference.

1–29. SYSTEM ON. To place Radar Set AN/APN-105 in full operating condition, turn the Mode Switch to the MAG position (DG position if the compass is utilizing a free gyro reference). Primary power and filament voltage are applied throughout the system when the panel lamps on the Control Indicator are

illuminated. The remaining power is applied after a one-minute delay, as indicated by the Bearing Distance Heading Indicator OFF flag disappearing from view.

1–30. SYSTEM OFF. To turn off Radar Set AN/APN-105, turn the Mode Switch to the OFF position. The Bearing Distance Heading Indicator OFF flag appears over the distance numerals when the Mode Switch is turned to the OFF position.

1–31. NORMAL OPERATION. Turn the Operate Switch to the NORM position. The proper heading reference must be selected by the Mode Switch, and the heading reference system must be energized and stabilized. Turn the Coordinate Display Switch to the DEST A position and set in the desired latitude and longitude coordinates by means of the slew lever associated with each counter. Depressing the slew lever only part way in either direction slews its counter slowly; full depression in either direction slews its counter at maximum speed. Turn the Coordinate Display Switch to the DEST B position and set in the latitude and longitude coordinates of the second destination by means of the same slew levers. To set in the present position coordinates, the Operate Switch must then be turned to the FIX position. Turn the Coordinate Display Switch to the PRES position and set in the present position coordinates by means of the slew levers. Turn the Operate Switch back to the NORM position and note that the present position coordinates remain the same. With the Operate Switch in the NORM position, the present position coordinates will shift only when the aircraft is in motion.

1–32. Radar Set AN/APN-105 is then ready for flight. Turn the Course Switch to the COURSE A position. Note that the course computation is computed to DEST A, the destination to which the Course Switch is set. The present position of the aircraft will be continuously displayed during flight as long as the Coordinate Display Switch is set to the PRES position.

1–33. Further adjustments or switching during flight may be called for if it is desired to correct the present position coordinates by reference to a check point (refer to paragraph 1–34), if radar silence is desired (refer to paragraph 1–37), if the flight is extended over water (refer to paragraph 1–38 and 1–39), if the first destination is reached and it is desired to compute the course to the alternate destination (refer to paragraph 1–44), or if a spiral search pattern is desired (refer to paragraph 1–45).

1–34. FIX PROCEDURE (Position Checking En Route). The flight may be planned over a location of known position. At the time the aircraft is directly over the location, its present position should be the same as the coordinates of the location. If the present position coordinates of the aircraft differ from the coordinates of the known location, the computed present position is in error by the amount of the difference. The erroneous present position indication may be corrected by resetting the latitude and longitude counters using the manual fix procedures described in paragraphs 1–35 and 1–36.

1–35. To perform a manual fix, ascertain the exact moment that the aircraft is directly over the fix check point. At this moment, turn the Operate Switch to the FIX position. This freezes the present position display regardless of the fact that the aircraft immediately passes the check point. Check the frozen present position coordinates against the coordinates of the check point. If necessary, reset the counters by means of the Slew Switches making the present position coordinates agree with the fix check point coordinates. Having corrected the present position of the aircraft as of the time it was over the fix check point, turn the Operate Switch back to the NORM position. Distance traveled by the aircraft during the time that the Operate Switch was in the FIX position was stored in the computer. When the Operate Switch is turned back to the NORM position, the stored distance readjusts the present position display, bringing the present position up to date. Thus, the present position display is again that of the aircraft, having the additional qualification of being corrected as of the last check point.

1–36. The fix storage capacity of the computer is limited and therefore, the fix procedure must be completed within certain limitations of aircraft travel. The latitude storage is limited to north-south changes in position of 102.4 minutes of latitude or 102.4 nautical miles. Similarly, the longitude storage is limited to east-west changes in position of 102.4 minutes of longitude which are 102.4 nautical miles at the equator. At $\pm 75.5°$ latitude, 102.4 minutes of longitude are equivalent to 25.6

nautical miles. Therefore, the longitude fix storage capacity in terms of miles is effectively reduced at higher latitudes. The fix procedure must be completed and the Operate Switch placed back in the NORM position before the fix storage circuits are filled. If the equipment is placed in fix and the distance traveled exceeds the above-noted limits, the count actually stored will be a random one. When the equipment is then placed back in normal operation, the stored distance supposed to have been traveled while in fix will be completely erroneous. In this case, the only way to correct the present position indication is to make another position check by reference to a check point.

1–37. RADAR SILENCE AND WIND MEMORY. Sometimes it becomes necessary during flight to discontinue transmission of microwave energy (a precaution against detection). To do this, turn the Operate Switch from the SEA or NORM position to the SIL position. This cuts off power to some of the transmitting circuits in the Antenna Unit. With no transmission and the resulting loss of doppler return, the MEMORY lamp on the Control Indicator will illuminate indicating that Radar Set AN/APN-105 is operating on wind memory. Whenever the Tracker Unit ceases tracking doppler return from any one or all beams, either by the instituting of radar silence or other reasons, the system will switch to memory operation and the MEMORY lamp will illuminate. In memory operation the last known wind velocity, before loss of doppler return, is retained in the wind memory circuits. This wind velocity is added to the airspeed input from the Air Data Computer (not part of Radar Set AN/APN-105). The combination of air speed and wind velocity form an approximate ground speed which replaces the velocity information normally obtained from the radar beams. This allows the computation of present position to continue uninterrupted. When the Tracker Unit locks on the returned signals once more, the system will return to normal and the wind memory circuit will resume computation of wind velocity.

1–38. SEA OPERATION. During a flight over a water mass the system has certain over-water bias errors because of the skewing effect on the doppler spectrum which is caused by the variation of scatter characteristics between land and water. These conditions can result in misleading doppler information unless some compensating factor is introduced in flights over water. This is accomplished by turning the Operate Switch to the SEA position just prior to going over the water. This will switch the system to a sea-state condition, thereby introducing a constant factor that will compensate for the over-water bias errors and insure true present position information. When leaving the water area, merely turn the Operate Switch back to the NORM position. If this sea-state procedure is neglected and the system operates on NORM over a water mass, the result will be an error of approximately 3 per cent in computation of the present position for the overwater distance traveled. The counters will indicate less travel than has actually occured.

1–39. A smooth sea will reflect much of the transmitted energy away from the aircraft and this could cause the system to go into memory operation. If, during an overwater flight, it is noted that the ground speed is low and drift angle erratic, place the system in memory operation by switching the Operate Switch to SIL. These symptoms indicate incorrect doppler return and greater accuracy will be obtained by placing the system into wind memory and using air speed data from the air data computer. The wind velocity which will be used from the wind memory circuit will be the last computed wind velocity prior to going into sea operation, as the computation of wind velocity stops when the system goes into sea operation. If the system is operating normally over water (proper ground speed and drift angle), the wind memory circuit can be up-dated to the present wind velocity by switching the Operate Switch to the NORM position for ten seconds, and then back to SEA.

1–40. DG MODE. (Transverse Coordinate System). Flights that extend beyond 75° latitude into polar regions must use the DG mode of navigation. This entails the use of special maps or transparent overlays, featuring a transverse coordinate system. With this arrangement the grid lines converge to a pole relocated to a position on the equator at the Greenwich Meridan, and the zero latitude line is thereby moved 90° so that it passes through the true north and south poles. There is no concentration of grid lines in the true polar regions. With the earth mass projected against this new grid system, particular locations have new latitude and longitude coordinates. These are the coordinates used for navigation in the DG mode.

1–41. To operate in the DG mode, turn the Mode Switch to the DG position and set the compass into the free gyro mode of operation. It is necessary to slew the Gyro Compass so that it is oriented with the transverse grids of polar operation. Set in the desired transverse destination coordinates and the transverse present position coordinates in the same manner described for normal operation. (See paragraph 1–30.) The equipment is then set to operate in the DG mode, and does so analogously to normal operation. The only distinction is the new set of transverse coordinates to which navigation is referred.

1–42. MAG MODE (Normal Coordinate System). Normal coordinates are used in the MAG mode of operation. In MAG operation, the Gyro Compass maintains its northward orientation by means of a magnetic flux valve. Radar Set AN/APN-105 compensates the heading signal for magnetic variation over the earth.

1–43. EMERGENCY. If the course angle, ground track, ground speed, drift angle or distance-to-destination displays should be erratic, the analog sections of the system may be defective. If this is the case, the present position display will still be correct since such display is primarily dependent upon the digital sections of the Present Position Computer. Observation of the present position display progress while in flight should indicate whether Radar Set AN/APN-105 up through the output of the Present Position Computer is functioning normally. The latitude and longitude present position counters should tick off one step for each 0.4 minute of latitude or longitude flown by the aircraft. If so, then only the analog sections are defective and the drift angle, course angle, ground track, ground speed or distance-to-destination displays should be disregarded.

1–44. SORTIES. To operate out of a home base to which the aircraft must return, slew one set of the destination coordinates to that of the home base. These coordinates will then be identical to the present position coordinates before take-off. The equipment continuously indicates the present position. When the return flight is commenced, switch in the home destination coordinates with the Course Switch and the course angle and distance-to-home-base will be displayed automatically.

1–45. SEARCHES. A spiral search pattern may be followed easily by setting the destination coordinates coincident with the present position. Fly the aircraft so that some minimum distance-to-destination is indicated and then steer approximately 93° off course. Following this path will trace out a spiral flight pattern whose origin is at the destination coordinates.

1–46. AN/APN-105 COOLING REQUIREMENTS.

1–47. The units of Radar Set AN/APN-105 contain no fans for cooling purposes. All units, except the indicators, are mounted on a single mounting assembly containing a plenum chamber. Air from the aircraft cooling system will pass into the units of the radar set according to figure 1–12.

1–48. Above 0°F (±3°), the plenum inlet air will divide evenly, 50% passing into the Present Position Computer and the other 50% bypassing the computer and going directly into the plenum chamber. The computer exhaust flows into the plenum and the total air flow then passes into the Antenna Unit, Modulator Unit, Tracker Unit and Power Supply in the following proportions:

Frequency Converter-Transmitter CV-448/APN-105	26%
Power Supply 60504	51%
Frequency Converter-Tracker 58003	16%
Frequency Converter-Transmitter 58002	7%

These four units exhaust air into the aircraft compartment through case ventilations.

1–49. Below 0°F (±3°), a thermal air choke will restrict the computer input air to only 5.6% of the total inlet air and therefore force more cold air directly into the plenum chamber. This will cause a pressure buildup in the plenum inlet resulting in a reduction of the total system air flow. The exhaust from the Present Position Computer returns to the plenum as before and follows the same distribution into the other four units.

1–50. The minimum inlet air flow to the plenum chamber vs the inlet air temperature is given in table 1–6. The plenum chamber is equipped with levers actuated by the presence of a unit, permitting air flow when the unit is installed, and shutting off the flow of air from the plenum chamber to a unit that has been removed.

Table 1–6. Minimum Inlet Air Flow vs Inlet Air Temperature

Inlet Temperature (°F)	Minimum Flow (lb/min)
−65 ±3 to 0 ±3	2.05
0 ±3	2.70
30	3.03
70	3.71
100	4.83
120	6.24

CAUTION

Other electronic units may be cooled from the same air supply. Any openings or leaks anywhere in the air distribution network will lower the pressure and result in a reduction of the airflow into the AN/APN-105 plenum chamber. This could result in overheating and breakdown of critical circuit components.

1–51. The heat dissipated by each unit is shown in table 1–7. The radar silence mode (Operate Switch in the SIL position) constitutes a standby condition. In this condition, the equipment will operate fully except for radiation of transmitter energy. The Present Position Computer will be in the memory mode. The heat dissipation of the Power Supply will increase since the power normally radiated is supplied to a dummy load within the Power Supply.

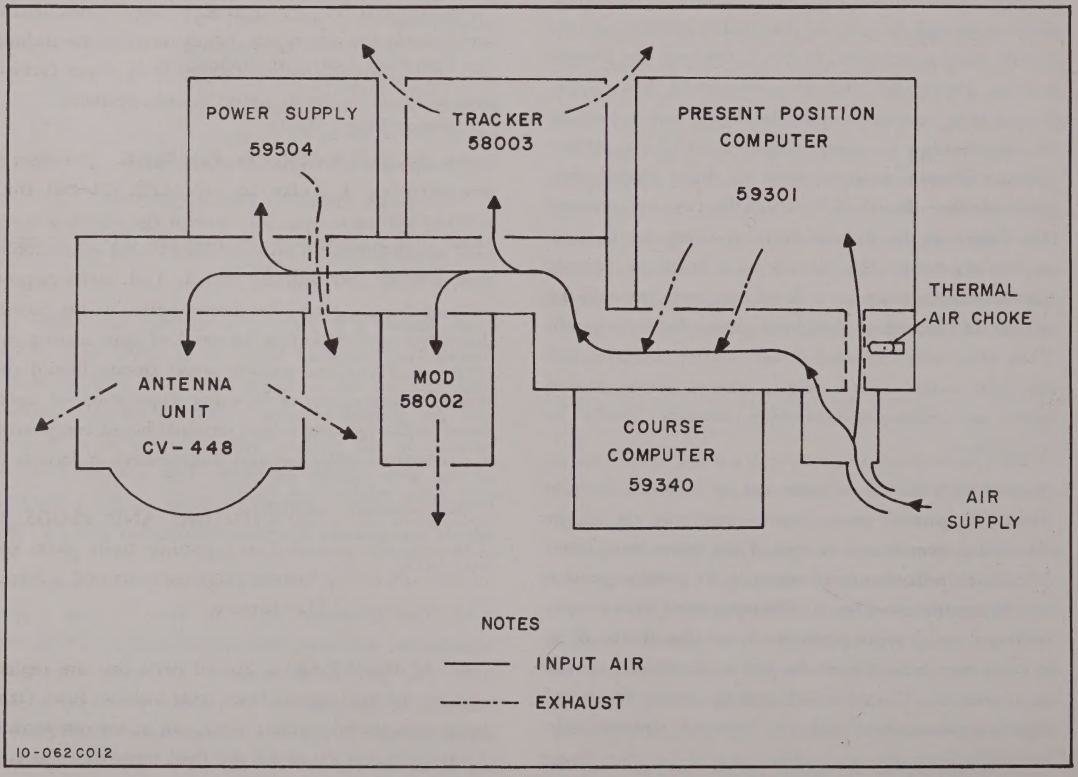

Figure 1–12. Air Distribution through Radar Set AN/APN105

Table 1–7. Heat Dissipation

Unit	Normal	Radar Silence
Frequency Converter-Transmitter CV-448/APN-105	198.5	136.0
Frequency Converter-Transmitter 58002	81.5	81.5
Frequency Converter-Tracker 58003	210.0	210.0
Computer Navigational, Position 60301	124.5	124.5
Computer, Navigational, Course 51868	48.0	48.0
Power Supply 60504	250.0	302.0
Control-Indicator 60932	7.0	7.0
Indicator, Drift-Angle-Ground Speed ID-617/APN-105	14.0	14.0
TOTAL	933.5	923.0

Note

During radar silence, the internal heat dissipation of the Power Supply increases since some of the power that is normally supplied to the Antenna Unit to operate transmitting circuits is dissipated through an internal dummy load.

1–52. FIELD MAINTENANCE.

1–53. GENERAL. Field maintenance of Radar Set AN/APN-105 consists of system maintenance and unit (black box) maintenance. System maintenance consists of simply locating the defective unit within the system and replacing it with a good one. Unit maintenance consists of locating the defective component or subassembly within the unit and installing a replacement.

1–54. System level test procedures are given in Section VI, for both flight line and bench troubleshooting. The flight line procedures are used when it is required to repair a system that is already installed in an aircraft. The bench procedures are used when a complete system is undergoing tests on the bench. This could occur during a periodic precision check or possibly as an incoming inspection check. Two sets of test procedures will be found for system troubleshooting on the flight line. One test procedure utilizes the two GPM-24 test carts while the other procedure makes use of Test Set, Radar 51392-1 and Voltage Deviation Monitor 51248-1.

1–55. Sections VII through XIV contain maintenance instructions for unit repair. No instructions are included for maintenance of subassemblies. Only depot facilities are equipped to repair defective subassemblies.

1–56. MOISTURE-PROOF COATING. The over-all requirements of Radar Set AN/APN-105 call for a moisture-proof coating for some of the circuit elements that are mounted on terminal boards and subassemblies that are not hermetically sealed. This moisture-proof coating (epoxy resin) has been applied at the factory. Extensive perforation or removal of this coating may result in circuit malfunction under certain humid conditions. Special instructions for application of epoxy resin, after replacing minor terminal board components, are contained under General Maintenance in Section VI.

1–57. POTTING CONNECTORS AND PLUGS. Instructions for replacing and potting front panel connectors and wiring harness plugs are contained in Section VI under General Maintenance.

1–58. SPARED PARTS. Spared parts that are replaceable on the field maintenance level includes fuses (table 1–8), subassemblies (table 1–9), and minor components. Table 1–10 is a list of all the field replaceable parts of Radar Set AN/APN-105.

Table 1–8. Fuses for Power Supply 60504

Fuse	Rating (amp)	Controls	Destination
F6001	12	+28V d-c	Power Supply 60504
F6002	6	115V a-c, /0°, 400 cps	Power Supply 60504
F6003	5	115V a-c, /+120°, 400 cps	Power Supply 60504 Computer, Navigational, Position 60301
F6004	5	115V a-c, /—120°, 400 cps	Power Supply 60504
F6005	0.175	+300V d-c	Computer, Navigational, Position 60301
F6006	0.175	—150V d-c	Frequency Converter-Tracker 58003 Frequency Converter-Transmitter CV-448/APN-105 Frequency Converter-Transmitter 58002
F6007	0.500	+150V d-c	Frequency Converter-Transmitter CV-448/APN-105 Frequency Converter-Tracker 58003
F6008	0.750	+125V d-c	Frequency Converter-Transmitter CV-448/APN-105 Frequency Converter-Transmitter 58002
F6009*	0.375	—500V d-c	Frequency Converter-Transmitter CV-448/APN-105
F6010*	0.175	—750V d-c	Frequency Converter-Transmitter CV-448/APN-105
F6011*	0.175	—1000V d-c	Frequency Converter-Transmitter CV-448/APN-105
F6012	1	—44V d-c —27V d-c	Computer, Navigational, Position 60301
F6013	1	+44V d-c	Frequency Converter-Transmitter CV-448/APN-105 Frequency Converter-Transmitter 58002 Computer, Navigational, Position 60301
F6014	0.750	+34V d-c	Frequency Converter-Transmitter CV-448/APN-105 Frequency Converter-Transmitter 58002 Computer, Navigational, Position 60301
F6015	5	+22V d-c +18V d-c	Frequency Converter-Transmitter CV-448/APN-105 Computer, Navigational, Position 60301
F6020	5	+28V d-c 60-sec delay	Computer, Navigational, Position 60301
F6021	3	+28V d-c delayed	Frequency Converter-Transmitter 58002
F6022	3	+28V d-c delayed	Frequency Converter-Transmitter CV-448/APN-105
F6023	3	+28V d-c control	Computer, Navigational, Position 60301

*F6009, F6010 and F6011 are located inside Power Supply 60504.

Table 1–9. Replaceable Subassemblies

Unit	Subassemblies
Frequency Converter-Transmitter 58002	Barometric pressure switch; any of three enclosed subassemblies.
Frequency Converter-Transmitter CV-448/APN-105	Klystron oscillator; set of three X-band amplifiers; holder-mounted crystal diodes; vertical gyro and calibration relay assembly; any of the enclosed subassemblies are replaceable in the field.
Frequency Converter-Tracker 58003	Any of the seven enclosed tracker subassemblies (books)
Computer, Navigational, Position 60301	Any of the 28 subassemblies (card; roll, pitch, or heading converters; air speed oscillator oven.
Computer, Navigational, Course 51868	Any of the 17 modules.
Power Supply 60504	Relay shelf; any of the transformers and reactors and the seven card subassemblies.
Control-Indicator 60932	Any of the enclosed subassemblies.
Indicator, Drift Angle-Ground Speed ID-617/APN-105	Replaced as a unit.

1–59. FIELD REPLACEABLE PARTS.

1–60. Table 1–10 is a list of all the spared subassemblies that are replaceable on the field maintenance level. Item numbers indicate the level of assembly. Each major assembly or unit is represented by a prefix letter. The following digits represent parts or further subassemblies on the next level. For example, A0200402 indicates an item in Frequency Converter-Transmitter CV-448/APN-105 by the prefix letter, A. The A02 portion represents an item or subassembly belonging to A. The following 004 represents an item or subassembly that is part of A02. The last portion of the item number, 02, is the last level and represents an item that is part of A02004. All part numbers are original vendor part numbers except when manufactured by the prime contractor or when design is controlled by the prime contractor. Nomenclature, wherever possible, is taken from Federal Supply Identification Guide H6-1. Vendor code numbers appear on the same line after the nomenclature. Prime contractor specification numbers appear under the vendor code numbers. A table of vendor codes, table 1–11, is given immediately after table 1-10. Quantity per unit is the amount of the item as it appears in the next higher assembly or subassembly. Quantity per system is the total amount of each different part per end article is listed in this column of table 1–10. An item appearing in the list for the first time will have an entry for this column. Any subsequent time the same item appears in the list, it will bear a "REF" in this column.

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
A	36850-1	FREQ. CONV-XMTR CV-448/APN-105	82598 36850-1	1	1
A02	38163-1	TRANSMITTER ASSEMBLY	82598 38163-1	REF	REF
A02002	BL168M	SEMICNDCTR DEV, DIODE SET CR101	96341 29834-1	5 pr	8 pr
A02004	37846-3	ELECTRON TUBE, KLYS V102	82598 37846-1	3	3
A02006	1XM1	ISOLATOR, RF, REFLECTN	49956 37522-1	1	1
A02008	1X17	ISOLATOR, RF, REFLECTN Z109	49956 36385-1	1	1
A02010	BL168M	SEMICNDCTR, DEV, DIODE CR111	96341 31723-1	1	2

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105 (Cont)

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
A02012	38087-1	ELECTRON TUBE, KLYS	82598	1	1
		V101	38087-1		
A04	38086-1	PANEL, PWR DISTRIBUTN	82598	REF	REF
			38086-1		
A04002	10-140	TERMINAL BRD	75173	1	1
		TB101	8757-10		
A04004	HP3.5C50D1	CAPACITOR, FIX, ELYTC	21520	2	4
		C101	27911-9		
A04006	MPF305M	CAPACITOR, FIX, PAPER	01884	2	2
		C103	32120-124		
A04008	LPC-3-ES-252-H	COIL, RF	71279	2	5
		L101	7174-12		
A04010	38379-1	BOARD, COMPONENT MTG	82598	1	1
			38738-1		
A06	36113-1	AMPLIFIER, IF	82598	3	3
			36113-1		
A08	T4130-1A T4130-3A-B	GYROSCOPE, DISPLACMNT	88818 26780-1	1	1
A10	37323-1	RELAY, ASSY, ANT CALIB	82598	1	1
			37323-1		
A12	36130-1	AMPLIFIER, FREQ STABL	82598	1	1
			36130-1		
A14	36234-1	ISOLATION FILTER	82598	1	1
			36234-1		
A16	37831-1	NETWORK, IMPDNC MTCHG	82598	1	1
			37831-1		
A18	40048-1	ANTENNA SUBSSY	82598	REF	REF
			40048-1		
A18002	38679	ISOLATOR, RF, RFLCTN		3	3
		Z105	36386-1		
A18004	BL168M	SEMICNDCTR DEV, DIODE	96341	1	REF
			31723-1		
A18006	BL168M	SEMICNDCTR DEV, DIODE	96341	3	REF
			29834-1		
A20	C4344	SWITCH, THERMOSTATIC	82598	1	1
		S101	38862-1		
A22	42028-1	CABLE ASSY, RF	82598	1	1
			42028-1		
A24	37291-1	CABLE ASSY, RF	82598	1	1
		W132	37291-1		
A26	37291-2	CABLE ASSY, RF	82598	1	1
		W133	37291-2		
A28	37291-3	CABLE ASSY, RF	82598	1	1
		W134	37291-3		
A30	37291-4	CABLE ASSY, RF	82598	1	1
		W141	37291-4		
A32	37291-5	CABLE ASSY, RF	82598	1	1
		W142	37291-5		
A34	37291-6	CABLE ASSY, RF	82598	1	1
		W122	37291-6		

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105 (Cont)

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
A36	37291-7	CABLE ASSY, RF	82598	1	1
		W117	37291-7		
A38	37291-8	CABLE ASSY, RF	82598	1	1
		W118	37291-8		
A40	37291-28	CABLE ASSY, RF	82598	1	1
		W116	37291-28		
A42	37291-9	CABLE ASSY, RF	82598	1	1
		W119	37291-9		
A44	37291-27	CABLE ASSY, RF	82598	1	1
		W115	37291-27		
A46	37291-10	CABLE ASSY, RF	82598	1	1
		W120	37291-10		
A48	37291-26	CABLE ASSY, RF	82598	1	1
		W135	37291-26		
A50	37291-11	CABLE ASSY, RF	82598	1	1
		W121	37291-11		
A52	37291-25	CABLE ASSY, RF	82598	1	1
		W138	37291-25		
A54			82598	1	1
			37291-12		
A56	37291-24	CABLE ASSY, RF	82598	1	1
		W136	37291-24		
A58			82598	1	1
			37291-13		
A60	37291-23	CABLE ASSY, RF	82598	1	1
		W139	37291-23		
A62			82598	1	1
			37291-14		
A64	37291-22	CABLE ASSY, RF	82598	1	1
		W137	37291-22		
A66			82598	1	1
			37291-15		
A68	37291-21	CABLE ASSY, RF	82598	1	1
		W140	37291-21		
A70			82598	1	1
			37291-16		
A72			82598	1	1
			37291-20		
A74			82598	1	1
			37291-17		
A76			82598	1	1
			37291-18		
B	58002-1	FREQ CONV-XMTR 58002	82598	1	1
			58002-1		
B02	I-47146E	BAROSWITCH	72737	1	1
		S201	29920-1		
B04	52983-1	SELECTR, GATE FREQ and GEN	82598	1	1
			52983-1		
B06	37159-1	FREQUENCY GENERATOR	82598	1	1
			37159-1		

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105 (Cont)

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
B08	35912-1	AMPLIFIER, RF	82598 35912-1	1	1
B10	38768-6	CABLE ASSY, RF W1	82598 38768-6	1	1
B12	38769-4	CABLE ASSY, RF W2	82598 38769-4	1	1
B14	38768-3	CABLE ASSY, RF W3	82598 38768-3	1	1
B16	38769-5	CABLE ASSY, RF W4	82598 38769-5	1	1
B18	37292-1	CABLE ASSY, RF W5	82598 37292-1	1	1
B20	38769-3	CABLE ASSY, RF W6	82598 38769-3	1	1
B22	38769-2	CABLE ASSY, RF W7	82598 38769-2	1	1
B24	38768-5	CABLE ASSY, RF W8	82598 38768-5	1	1
B26	38768-1	CABLE ASSY, RF W9	82598 38768-1	1	1
B28	38768-4	CABLE ASSY, RF W10	82598 38768-4	1	1
B30	38769-1	CABLE ASSY, RF W11	82598 38769-1	1	1
B32	38768-2	CABLE ASSY, RF W12	82598 38768-2	1	1
B34	3S2791G201F-9	RELAY, ARMATURE K201	01526 36902-8	1	1
C	60504	POWER SUPPLY 60504	82598 38140-1	1	1
C02	59115-1	REGULATOR and RELAY ASSY	82598 37060-1	1	1
C04	59105-1	TRANSFORMER ASSY	82598 36849-1	REF	REF
C04002	40231-6	TRANSFORMER POWER, U and D T6005	82598 40231-1	1	1
C04004	43963-1	TRANSFORMER POWER, U and D T6006	82598 40232-1	1	1
C04006	43962-1	TRANSFORMER POWER, U and D T6001	82598 40230-1	1	1
C04008	38610-1	TRANSFORMER, POWER T6004	82598 38610-1	1	1
C04010	38733-1	TRANSFORMER, POWER T6003	82598 38733-1	1	1
C04012	49641-1	SATURABLE REACTOR L6003	82598 38611-1	3	3
C06	37808-1	CARD UNIT ASSY	82598 37808-1	REF	REF
C06002	51771-1	CARD SUBSSY, PWR SUP A6004	82598 37809-1	1	1

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105 (Cont)

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
C06004	37810-1	CARD SUBSSY, PWR SUP A6005	82598 37810-1	1	1
C08	37802-1	CARD UNIT ASSY	82598 37802-1	REF	REF
C08002	51537-1	CARD SUBSSY, PWR SUP A6002	82598 37803-1	1	1
C08004	37804-1	CARD SUBSSY, PWR SUP A6003	82598 37804-1	1	1
C10	59237	CARD UNIT ASSY	82598 37805-1	REF	REF
C10002	37806-1	CARD SUBSSY, PWR SUP A6001	82598 37806-1	1	1
C10004	37807-1	CARD SUBSSY, PWR SUP A6006	82598 37807-1	1	1
C12	314.012	FUSE, CARTRIDGE F6001	75915 19725-7	2	2
C14	312.006	FUSE, CARTRIDGE F6002	75915 8437-12	5	5
C16	312.175	FUSE, CARTRIDGE F6005	75915 8437-26	8	8
C18	312.005	FUSE, CARTRIDGE F6015	75915 8437-10	7	7
C20	312.500	FUSE, CARTRIDGE F6007	75915 8437-5	6	6
C22	312.001	FUSE, CARTRIDGE F6012	75915 8437-6	4	4
C24	312.008	FUSE, CARTRIDGE F6019	75915 8437-14	2	2
D	38428-1	COMPUTER, NAVIG 60301	82598 38428-1	1	1
D02	37175-1	CARD SUBSSY, NAV COMP A2101	82598 37175-1	1	1
D04	35941-1	CARD SUBSSY, NAV COMP A2102	82598 35941-1	1	1
D06	37176-1	CARD SUBSSY, NAV COMP A2103	82598 37176-1	1	1
D08	37177-1	CARD SUBSSY, NAV COMP A2104	82598 37177-1	1	1
D10	37178-1	CARD SUBSSY, NAV COMP A2105	82598 37178-1	1	1
D12	59070	CARD SUBSSY, NAV COMP A2106	82598 37179-1	1	1
D14	37180-1	CARD SUBSSY, NAV COMP A2107	82598 37180-1	2	2
D16	37181-1	CARD SUBSSY, NAV COMP A2108	82598 37181-1	1	1
D18	37182-1	CARD SUBSSY, NAV COMP A2109	82598 37182-1	1	1
D20	37183-1	CARD SUBSSY, NAV COMP A2110	82598 37183-1	2	2

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105 (Cont)

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
D22	37184-1	CARD SUBSSY, NAV COMP A2111	82598 37184-1	1	1
D24	37185-1	CARD SUBSSY, NAV COMP A2112	82598 37185-1	2	2
D26	59099	CARD SUBSSY, NAV COMP A2113	82598 37186-1	1	1
D28	35747	CARD SUBSSY, NAV COMP A2114	82598 37187-1	1	1
D30	37188-1	CARD SUBSSY, NAV COMP A2115	82598 37188-1	3	3
D32	37189-1	CARD SUBSSY, NAV COMP A2116	82598 37189-1	1	1
D34	59072	CARD SUBSSY, NAV COMP A2122	82598 36476-1	1	1
D36	51730	CARD SUBSSY, NAV COMP A2123	82598 35963-1	1	1
D38	35797-1	CARD SUBSSY, NAV COMP A2124	82598 35797-1	1	1
D40	35747-1	CARD SUBSSY, NAV COMP A2125	82598 35747-1	1	1
D42	51846	CARD SUBSSY, NAV COMP A2126	82598 36151-1	1	1
D44	59216	CARD SUBSSY, NAV COMP A2127	82598 36406-1	1	1
D46	59074	CARD SUBSSY, NAV COMP A2128	82598 36525-1	1	1
D48	36319-1	CARD SUBSSY, NAV COMP A2129	82598 36319-1	1	1
D50	59104-1	CENTER SECT. NAV COMP	82598 38400-1	REF	REF
D50002	38883-1	OVEN, AIRSPD OSC, ASSY Z3751	82598 38883-1	1	1
D50004	38744-1	CONVERTER, ANLOG-DGTL Z1302	82598 27484-1	2	2
D50006	57852-3	CONVERTER, ANLOG-DGTL Z1301	82598 27461-1	1	1
E	Y7000-11N	COMPUTER, NAVIG 51868	88818 36462-1	1	1
E02	C200-000-103	COMP, NAV, SUBSSY	88818 C200-000-103	REF	REF
E02002	C200-000-049	MECH ASSY, PRES POS	88818 C200-000-049	2	2
E02004	C200-000-050	MECH ASSY, DESTN LONG	88818 C200-000-050	2	2
E02006	C200-000-697	MECH ASSY, DESTN LAT	88818 C200-000-051	2	2
E02008	C200-000-052	MECH ASSY, PRES POS LAT	88818 C200-000-052	1	1
E01010	C200-000-053	MECH ASSY, PRES POS LNG	88818 C200-000-053	1	1

Table 1–10. Field Replaceable Parts of Radar Set AN/APN-105 (Cont)

Item Number	Part Number	Nomenclature		Qty Unit	Qty System
E02012	C200-000-63	MECH ASSY, DESTN SLEW	88818 C200-000-063	2	2
E02014	C200-000-061	MECH ASSY, DESTN DIF LONG	88818 C200-000-061	1	1
E02016	C200-000-104	MECH ASSY, DESTN DIF LAT	88818 C200-000-104	1	1
E02018	C200-000-072	MECH ASSY, HEADING IND	88818 C200-000-072	1	1
E02020	C200-000-073	MECH ASSY, DIST/DESTN	88818 C200-000-073	1	1
E02022	C200-000-089	MECH ASSY, MAGNTC VAR	88818 C200-000-089	1	1
E02024	C200-000-092	RELAY ASSY, LATITUDE	88818 C200-000-089	1	1
E02026	C200-000-093	RELAY ASSY, LONGITUDE	88818 C200-093	1	1
F	N9001-11N	CONTROL-INDICATOR 60932	88818 36553-1	1	1
F02	C200-000-097	CONTROL INDICATOR SUBSSY	88818 C200-000-097	REF	REF
F02002	C200-000-075	MECH ASSY, CONTROL IND	88818 C200-000-075	REF	REF
F0200202	R119-2A	MOTOR, CONTROL	88818 R119-2A	1	2
F0200204	R1001-1A	SYNCHRO, CONTROL TRANS	88818 R1001-1A	4	4
F0200206	B422-80A	COUNTER, ROTATING, FIX	88818 B422-80A	1	1
F0200208	B422-70A	COUNTER, ROTATING, FIX	88818 B422-70A	1	1
F04	C200-000-074	KNOB ASSEMBLY	88818 C200-000-074	2	2
G	36892-1	IND, DFT ANGLE-GND SPD ID-617	82598 36892-1	1	1
H	58003-1 59282-1	FREQ CONV-TRCKR CV-447	82598 58003-1	1	1
H02	51492	DEMODULATOR	82598 59282-1	1	1
H04	38185-1	CEF, SIDE AND FREQ GROUP	82598 38185-1	1	1
H06	51632-1	CEF, FORE and AFT	82598 51632-1	1	1
H08	59281-1	SENSE DETECTOR	82598 59281-1	1	1
H10	51764-1	TRACKER, SIDE	82598 51764-1	1	1
H12	51763-1	TRACKER, AFT	82598 51763-1	1	1
H14	51762-1	TRACKER, FORE	82598 51762-1	1	1
H16	38367-1	PRINTED CKT BRD	82598 38367-1	1	1

Table 1–11. Manufacturers' H4-1 Code

Code	Vendor's Name and Address
00136	McCoy Electronics Co., Mt. Holly Springs, Pa.
01002	General Electric Co., Capacitor Department of Transformer and Allied Products Division of Apparatus Group, Hudson Falls, N. Y.
01121	Allen-Bradley Co., Milwaukee, Wis.
01281	Pacific Semiconductors, Inc., Culver City, Calif.
01295	Texas Instruments, Inc., Components Div., Dallas, Tex.
01526	G. E. Co. Specialty Control Dept. of Apparatus Group, Waynesboro, Va.
01884	Dearborn Electronic Laboratories, Inc., Chicago, Ill.
02005	Haydon Switch, Inc., Waterbury, Conn.
03508	General Electric Co., Semi-Conductor Products Department of Electronic Components Division of Electronic, Atomic and Defense Systems Group, Syracuse, N. Y.
03877	Transitron Electronics Corp., Wakefield, Mass.
07387	Birtcher Corp., N. Los Angeles, Calif.
14655	Cornell Dubilier Electric Corp., South Plainfield, N. J.
21520	Fansteel Metallurgical Corp., North Chicago, Ill.
25244	Globe Union, Inc., Milwaukee, Wis.
40228	Micro Switch Div. of First Industrial Corp., Freeport, Ill.
40931	Minneapolis - Honeywell Regulator Co., Minneapolis, Minn.
45681	Parker Appliance Co., Cleveland, Ohio
49956	Raytheon Mfg. Co., Waltham, Mass.
53705	Scovil Mfg. Co., Waterbury, Conn.
56289	Sprague Electric Co., North Adams, Mass.
70309	Allied Control Co., Inc., New York, N. Y.
71279	Cambridge Thermionic Corp., Cambridge, Mass.
71468	Cannon Electric Co., Los Angeles, Calif.
72132	Electro Chemical Engraving Co., Inc. New York, N. Y.
72136	Electro Motive Mfg. Co., Willimantic, Conn.
72737	Giannini, G. M., and Co., Inc., Pasadena, Calif.
72962	Elastic Stop Nut Corp. of America, Union, N. J.
73293	Hughes Aircraft Co., Los Angeles, Calif.
73899	J F D Mfg. Co., Inc., Brooklyn, N. Y.
75042	International Resistance Co., Philadelphia, Pa.
75173	Jones, Howard B., Div. of Cinch Mfg. Corp., Chicago, Ill.
75915	Littlefuse, Inc., Chicago, Ill.
79500	Westinghouse Elec. Corp., Pittsburgh, Pa.
80033	Prestole Corp., Toledo, Ohio
80483	Aladdin Industries, Inc., Nashville, Tenn.
81312	Winchester Electronics Co., Glenbrook, Conn.
81349	Military Specifications
81350	Joint Army-Navy Specifications

Table 1–11. Manufacturers' H4-1 Code (Cont)

Code	Vendor's Name and Address
81453	Raytheon Mfg. Co., Receiving Tube Div., Newton, Mass.
81483	International Rectifier Corp., Los Angeles, Calif.
81640	Hetherington, Inc., Sharon Hill, Pa.
81860	Barry Corp., Watertown, Mass.
82598	Laboratory for Electronics, Boston, Mass.
83144	Flexible Tubing Corp., Bradford, Conn.
83186	Victory Engineering Corp., Newark, N. J.
86335	Glenco Corp., Metuchen, N. J.
88818	Kearfott Co., Inc., Little Falls, N. J.
90484	Suprenant Mfg. Co., Clinton, Mass.
91146	Diamond Mfg. Co., Wakefield, Mass.
91491	Anton Electronic Laboratories, Inc., Brooklyn, N. Y.
91637	Dale Products, Inc., Columbus, Nebr.
93201	G. E. Co., Compnt. Prod. Div. of Ind. Prod. Group, Schenectady, N. Y.
93332	Sylvania Electric Products, Inc., Electronics Div., Boston, Mass.
94603	Waters Manufacturing, Inc., Waltham, Mass.
95238	Continental Connector Corp., Long Island City, N. Y.
95987	Weckesser Co., Chicago, Ill.
96214	Texas Instruments, Inc., Dallas, Tex.
96341	Microwave Associates, Inc., Boston, Mass.
96451	Eastern Precision Resistor Corp., Brooklyn, N. Y.
98278	Felts Corp., Microdot Div., South Pasadena, Calif.
98350	Daystrom Pacific Corp., Santa Monica, Calif.
98978	International Electronic Research Corp., Burbank, Calif.
99378	Atlas, E. E. Corp., Bedford, Mass.
99699	Filtors, Inc., Port Washington, N. Y.
99942	National Semi-Conductor Products Div., Nat. Fab. Prod., Inc., Evanston, Ill.

SECTION II
PREPARATION FOR USE AND RESHIPMENT

2–1. APPLICABILITY.

2–2. Radar Set AN/APN-105 is installed in the aircraft by the contractor. Therefore, installation instructions are not applicable in this handbook. Instructions for unpacking and repacking the major units, and their subassemblies for shipment to the depot repair facility are given in the following paragraphs.

2–3. UNPACKING.

2–4. All major units and subassemblies of the AN/APN-105 Radar System are packaged and packed in accordance with Method II of MIL-P-116C.

Note

Care should be used in unpacking replacement parts, in that, when possible, the packaging material may be reused in packing the defective parts for return to the depot repair facility.

2–5. The corrugated boxes shall be opened only at the taped seams at the bottom. The moisture vapor-proof barriers shall be opened by cutting off the bottom seam. The humidity indicator card located within the barrier shall be inspected for indication of high humidity within the barrier. High humidity could possibly cause rust damage.

Note

Unless a major unit being unpacked is to be used immediately, leave the inner wrapping containing the carrying straps intact.

2–6. The Frequency Converter-Transmitter CV-448/APN-105 (Antenna Unit) has a wooden lens protector bolted to the equipment casing (see figure 2–1). This lens protector must not be removed until the Antenna Unit is about to be installed in the aircraft. The protector will prevent the lens from being damaged prior to installation of the Antenna Unit. The protector shall be salvaged along with the packing for reuse in reshipment of a defective Antenna Unit.

2–7. REPACKING.

2–8. Each major unit or subassembly of the system shall be repacked and repackaged to conform to the requirements of Method III of MIL-P-116C.

2–9. Repacking procedures are the reverse of unpacking procedures. Use that material salvaged from the replacement part or other available material that will afford the same physical and mechanical protection as the original package.

CAUTION

a. Be sure to block the front and back of each component piece of equipment with the corrugated fiber board pads of the original package or similar substitute material that will adequately protect the projections on the equipment from being damaged by, or damaging, the corrugated box.

b. Be sure to attach and bolt the lens protector to the Antenna Unit casing (see figure 2–1) before sealing the container.

2–10. When possible, use the original corrugated shipping boxes that comply with PPP-B-636. If necessary, a nailed wooden box may be used providing it is in accordance with PPP-B-621.

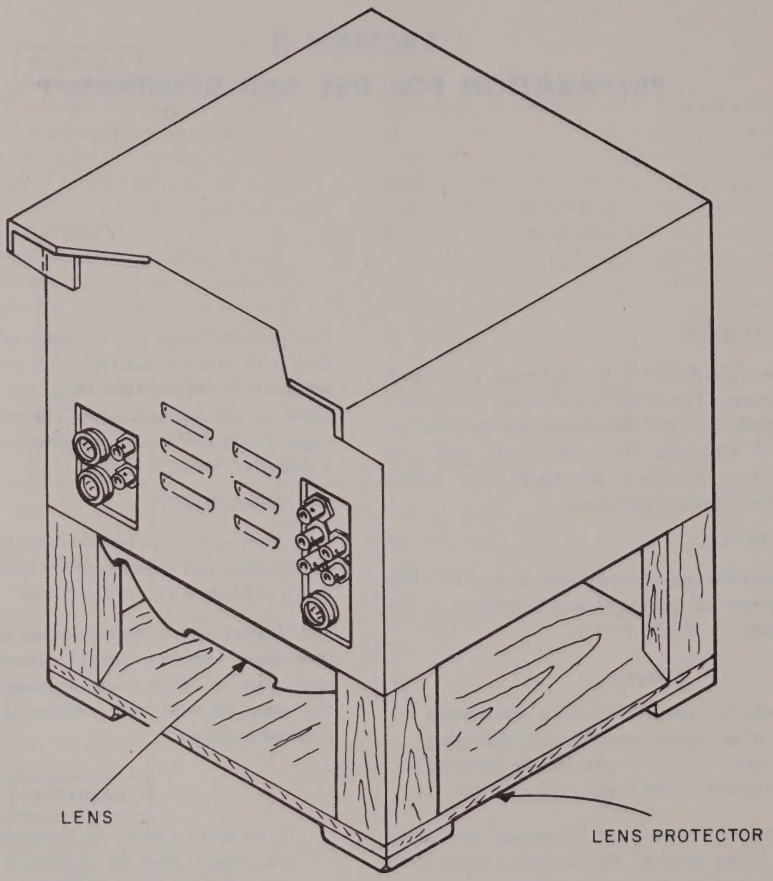

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Figure 2–1. Frequency Converter-Transmitter CV-448 AN/APN-105 (Antenna Unit)

SECTION III
TEST EQUIPMENT AND SPECIAL TOOLS

3-1. GENERAL

3-2. This section contains a list of field test equipment and special tools necessary (table 3-1 and 3-2) to maintain Radar Set AN/APN-105. Illustrations pertaining to test equipment and special tools are shown in figures 3-1 through 3-12. Instruction books encompassing the use of the test equipment are supplied with the applicable unit.

CAUTION

When servicing the Antenna Unit, be sure to use the beryllium type tools that are a part of Antenna Bench 58470-1 (see table 3-1).

3-3. The quantity of all the items listed is one unless otherwise specified.

NOTE

Specific models of test equipment illustrated herein may not be the actual items eventually authorized in Air Force allowance documents.

Table 3-1. Test Equipment Required for Maintenance

Figure and Index No.	FS Number	Nomenclature	Part No. LFE	Use
3-1	6625-771-8816	Test Set, Radar AN/GPM-24 (XY-2), Part No. 49665-1	49665-1	Used to test and troubleshoot Radar Sets AN/APN-131 and AN/APN-105.
3-2	6625-783-7621	. Test Set, Radar, Part No. 49738-1	49738-1	Specially designed vehicle used for troubleshooting and testing Radar Sets AN/APN-131 and AN/APN-105.
	6625-833-0071	. . Test Set, Radar TS-1054 (XY-4), Part No. 60370-1	60370-1	Used to test the transmitter power output, the switching of the Modulator Unit baroswitch, and to monitor the AGC output of the i-f amplifiers.
	6625-813-2349	. . Generator, Signal SG-225 (XY-1), Part No. 43433-1	43433-1	Used to generate three noise signals for testing the Frequency Converter-Tracker.
	6625-824-8865	. . Generator, Signal SG-226 (XY-4), Part No. 60369-1	60369-1	Used to simulate input signals to the Computer, Navigational Position (PPC).
	6625-813-2075	. . Power Supply, PP-1718 (XY-1), Part No. 43423-1	43423-1	Used to supply d-c operating voltages to the Test Set, Radar 49738-1.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-790-0775	. . Monitor, Voltage Deviation ID-640 (XY-2), Part No. 43863-1	43863-1	Used to check the d-c voltages from the radar system Power Supply.
		. . Counter, Electrical, ID-616 (XY-2), Part No. 60366-1	60366-1	Used to count signal pulses from the Tracker or the Present Position Computer. Also used to count the tachometer output from the TS-1054.
	6625-812-7641	. . Simulator, Gyro Signal SM-109 (XY-1), Part No. 43422-1	43422-1	Used to simulate pitch, roll and heading angles. Also displays pitch, roll and heading readouts.
	6625-710-9158	. . Cabinet Electrical Equipment CY2139, (XY-3) Part No. 60367-1	60367-1	Houses all the individual test units of Radar, Test Set, 49738-1.
	6625-815-5461	. Horn, Waveguide, Part No. 49819-1	49819-1	Used to provide simulated doppler return to the Antenna Unit.
3–3	6625-813-2345	. Test Set, Radar, Part No. 49234-1	49234-1	Specially designed test facility for testing and troubleshooting Radar Sets AN/APN-131 and AN/APN-105.
	6625-790-0777	. . Simulator Group, Part No. 49235-1	49235-1	Dummy loads the Power Supply and checks the operation of the barometric switch in the Modulator Unit.
	6625-819-1243	. . Generator Signal, Part No. 52901-1	52901-1	Used to test the adder circuit in the Frequency Converter-Tracker.
	6625-709-0778	. . Indicator, Angle Position, Part No. 49238-1	49238-1	Used to measure the angular position of rotating electromechanical components.
	6625-790-0779	. . Voltmeter, Electronic, Phase Sensitive, Part No. 49239-1	49239-1	Used to measure the amplitude and phase/angle of any 400 cps signal or any 400 cps a-c voltage from zero to 300 volts.
	6625-783-7622	. . Adapter, Test Computer, Part No. 52766-1	52766-1	Used as a convenient method to test the analog outputs of the doppler system.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-790-4137	. . Cabinet, Electrical Equipment, Part No. 49241-1	49241-1	Used to house all the individual test units of Radar Test Set 49234-1.
	6625-790-0780	. . Adapter, Cable Breakout, Course, Part No. 49244-1	49244-1	Used to troubleshoot the modules in the Course Computer.
3–4	6625-791-1023	Test Set, Radar	51392-1	Used to supply the facilities needed to support Flight-line maintenance of the AN/APN-131 or AN/APN-105 Doppler Radar Systems.
	6625-791-1025	. Test Set, Radar	54144-1	Used to isolate a malfunction within Radar Set AN/APN-131 or AN/APN-105 to a particular unit (other than the Power Supply) of the Set.
	.....	. . Cable Set, Patch (Set of 8)	57982-1	Used for the repair and troubleshooting of the test set.
	6625-737-9501	. Horn and Cable Assembly Kit	60082-1	This kit is made up of the following items.
	6625-791-1026	. . Horn, Waveguide	54161-1	Used to provide simulator doppler return to the Antenna Unit.
	6625-815-6843	. . Interconnecting Box	57667-1	Used to supply aircraft power simultaneously to the Radar Set and to the Radar Test Set.
	6625-475-4353	. . Case, Cable Assembly	60758-1	Used to store and transport the horn, interconnecting box, cable adapter and the cable set.
		. . Receptacle, Storage	60706-1	Used to protect the Cable connector during transit.
		. . External Cable Set	57981-1	Used to connect the test set to the AN/APN-131 System as shown below.
		. . . Cable Assembly, RF, 4W1	52809-1	Connects J18 to J8107 on Tracker Unit.
		. . . Cable Assembly, RF, 4W2	52800-1	Connects J22 to r-f horn.
		. . . Cable, Electrical, Special Purpose, 4W3	52801-1	Connects J2 to J110 on Antenna Unit.
		. . . Cable, Electrical, Special Purpose, 4W4	52802-1	Connects J4 to J8108 on Tracker Unit.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
		. . . Cable, Electrical, Special Purpose, 4W5	52803-1	Connects J3 to J202 on Modulator Unit.
		. . . Cable, Electrical, Special Purpose, 4W6	52804-1	Connects J5 to J5006 on Course Computer.
		. . . Cable, Electrical, Special Purpose, 4W7	52805-1	Connects J8 to J1306 on PPC.
		. . . Cable, Electrical, Special Purpose, 4W8	52806-1	Connects J7 to J1309 on PPC.
		. . . Cable, Electrical, Special Purpose, 4W9	52807-1	Connects J6 to J1310 on PPC.
		. . . Cable, Electrical, Special Purpose, 4W10	52808-1	Connects J9 to J1308 on PPC.
		. . . Cable Assembly, RF, 4W11	52809-2	Connects J15 to J8103 on Tracker Unit.
		. . . Cable Assembly, RF, 4W12	52809-3	Connects J14 to J8102 on Tracker Unit.
		. . . Cable Assembly, RF, 4W13	52809-4	Connects J13 to J8101 on Tracker Unit.
		. . . Cable Assembly, RF, 4W14	52809-5	Connects J21 to J1303 on PPC.
		. . . Cable Assembly, RF, 4W15	52809-6	Connects J20 to J1302 on PPC.
		. . . Cable Assembly, RF, 4W16	52809-7	Connects J19 to J1301 on PPC.
		. . . Cable Assembly, RF, 4W17	52809-8	Connects J16 to J8105 on Tracker Unit.
		. . . Cable Assembly, RF, 4W18	52809-9	Connects J17 to J8106 on Tracker Unit.
		. . . Cable, Electrical, Special Purpose, 4W19	60836-1	Connects interconnecting box to aircraft power when checking AN/APN-131 system.
		. . . Cable, Electrical, Special Purpose, 4W20	66658-1	For maintenance of the R-F Suitcase.
		. . . Cable, Electrical, Special Purpose, 4W21	66659-1	For maintenance of the R-F Suitcase.
		. . . Adapter, Connector, 4CP1	57110-2	To adapt interconnecting box to AN/APN-131 Power Supply.
3–5	6625-791-1019	Monitor, Voltage Deviation	51248-1	Used as a self-contained test equipment to support Radar Set AN/APN-105 or AN/APN-131 during testing procedures performed in the aircraft.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-791-1024	. Monitor, Voltage Deviation	52666-1	Used at the aircraft flight-line to monitor all output voltages of the Radar Set Power Supply and to dummy load the Power Supply.
	6625-739-1384	. . Cover, Test Set	52529-1	Used to protect the front panel in transit. It is also used to store spare fuses, spare lamps and an equipment handbook.
	6625-737-9502	. Cable Assembly Kit	60081-1	This kit is made up of the following items.
	6625-833-8924	. . Case, Cable Assembly	60415-1	The case is used to contain the following items which connect the Voltage Deviation Monitor to the Radar Set.
	6625-815-6842	. . Interconnecting Box	51258-1	Used to supply aircraft power simultaneously to the Radar Set Power Supply and to the Voltage Deviation Monitor.
		. . Cable Assembly, Special Purpose, Electrical, 3W9	60787-1	Used to connect into voltage lines of the Radar Set AN/APN-105 or AN/APN-131 Power Supply for monitoring and dummy loading the unit.
		. . Cable Assembly Set, Electrical, Group 1	52403-1	
		. . Cable Assembly Set, Electrical, Group 2	52403-2	
		. . Cable Assembly Set, Electrical, Group 3	52403-3	
		. . Cable Assembly Set, Electrical, Group 4	52403-4	
		. . Adapter, Connector	55226-1	Used to make the Monitor, Voltage Deviation compatible with both Radar Sets AN/APN-105 and AN/APN-131.
		. . Adapter, Connector	55226-2	
		. . Adapter, Connector	55226-4	
3–6	6625-445-9303	Test Bench System, Radar	58461-1	Used to supply all special facilities and special test equipment needed to support hanger maintenance of the AN/APN-131 and AN/APN-105 Doppler Radar System.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
3–7	6625-592-4333	. Test Bench Set, Mock-up	58471-1	Used as a work bench and packing box. It is also used to house a complete AN/APN-131 system as a test system.
	6625-592-4326	. . Test Bench Group, Mock-up	61127-1	This group consists of the next five items.
	6625-592-4316	. . . Test Bench, Radar Maintenance	61128-1	Consists of the next two items.
		. . . . Test Bench, Mock-up	61150-1	Used as a work bench and to house most of the test system.
	6625-722-6944	. . . . . Cover, Test Bench	64765-1	Used as a rear board when the bench is installed for use and as a front cover when packed for transit.
	6625-602-8175	. . . Monitor, Voltage and Current Deviation	61182-1	Used to check the a-c and d-c voltages, the d-c ripple and direct currents from the power supply.
	6625-797-0236	. . . Panel, Power Distribution	48438-1	Provides the necessary controls, fuses and meters for monitoring and adjusting the input power.
	6625-592-4175	. . Cable Duct, Mock-up Bench	** 58306-1	Used to provide easy access for cable connections to units.
	6625-592-4307	. . Stand, Unit Cooling, Universal (3 each)	* 61120-1	Used as a mounting for a unit under test and for a cooler.
	6625-592-4299	. . . Plenum Chamber, Universal	* 61121-1	Used to direct the air flow to the units under test.
	6625-592-4311	. . . Cooler, Air, Electronic Equipment	* 47806-2	Used to move air through the plenum chamber.
		. . Adapter Assembly No. 1, (Tracker)	55207-1	Used to direct the airflow to critical hot spots when the Tracker is removed from its case.
		. . Adapter Assembly No. 2, (Power Supply)	** 55539-1	Used to direct the airflow to critical hot spots when the AN/APN-131 Power Supply is removed from its case.
	6625-592-4311	. . Cooler, Air, Electronic Equipment (3 each)	47806-2	Used to circulate cooling air to the plenum chambers within the Mock-up Bench.
	6625-797-0249	. . Cooler, Air, Electronic Equipment	55570-1	Used to circulate additional cooling air as required to a unit under test which has been removed from its case.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
		. . Adapter, Connector, Style 1	50002-1	Used to adapt the wiring and connectors of the Test Bench System Radar to the connector and wiring requirements of the AN/APN-105 Radar Set.
		. . Adapter, Connector, Style 1	50002-2	
		. . Adapter, Connector, Style 1	50002-4	
		. . Adapter, Connector, Style 1	50002-5	
		. . Adapter, Connector, Style 1	50002-6	
		. . Adapter, Connector, Style 1	50002-7	
		. . Adapter, Connector, Style 1	50002-8	
		. . Adapter, Connector, Style 2	50003-1	
		. . Adapter, Connector, Style 3	50004-1	
		. . Adapter, Connector, Style 4	57753-1	
		. . Adapter, Connector, Style 4	57753-3	
3–8	6625-592-4210	. Test Bench Set, Antenna	58470-1	Used as a work bench and packing box. It is also used to house the equipment that tests the r-f/i-f group of Radar Sets AN/APN-131 or AN/APN-105.
	6625-602-8124	. . Test Bench Group, Antenna	58473-1	This group is made up of the next four items.
	6625-602-8101	. . . Test Bench, Radar Maintenance	58475-1	Used as a work bench and to house the r-f/i-f components of the system under test or the test system.
	6625-797-0236	. . . Panel, Power Distribution	48438-1	Provides the necessary controls, fuses and meters for monitoring and adjusting the input power.
	6625-602-8018	. . . Power Supply, Antenna	58477-1	Used to provide all power to the r-f/i-f components mounted on the bench. Control features are provided to expedite unit test of these components.
	6625-592-4198	. . . Anechoic Chamber	58326-1	Used to function as a known microwave attenuator and as a three-channel doppler simulator.
	6625-592-4170	. . Cable Duct, Antenna	64735-1	Used to provide mechanical support to cabling and cable distribution.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-592-4233	. . Test Set Group, Frequency Converter-Tracker	* 58304-1	Used as a self-contained test set to perform unit testing of the Frequency Converter-Tracker.
	6625-735-2617	. . . Cabinet, Electrical Equipment	* 64738-1	Used to contain, protect and provide air distribution to the next three units.
	6625-602-8146	. . . Generator, Signal I.F.	* 58321-1	Used to test the accuracy of the Frequency Converter-Tracker. The simulated doppler output is shifted from 500kc by the amount dictated by the next unit.
	6625-592-4234	. . . Selector, Doppler, I.F.	* 64752-1	Used to provide doppler modulation frequencies for the I-F Signal Generator.
	6625-602-8143	. . . Power Supply, Tracker	* 58322-1	Used to supply all the power to the Tracker under test and the Test Set Group, Frequency Converter-Tracker.
	6625-592-4227	. . Test Set Group, Frequency Converter-Transmitter	* 58305-1	Used as a self-contained test set to perform unit testing of the frequency Converter Transmitter Units. It is also used as a r-f signal source during system testing of the entire APN-131 or 105 Radar Set.
	6625-735-2618	. . . Cabinet, Electrical Equipment	* 64739-1	Used to contain, protect and provide air distribution to the next three units.
	6625-602-8142	. . . Simulator, Altitude	* 58325-1	Used to operate and check the outputs of the barometric switch in the Modulator Unit.
	6625-602-7930	. . . Generator, Signal R.F.	* 58324-1	Used to provide an accurately known doppler return to the Antenna Unit.
	6625-602-8125	. . . Power Supply, Antenna Test	* 64751-1	Used to supply electrical power to Test Set Group, Frequency Converter Transmitter.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-592-4312	. . Stand, Unit Cooling	*** 61124-1	Used as an air distribution assembly for the Antenna and Modulator Units of Radar Set AN/APN-131 or 105.
	6625-797-0238	. . . Plenum Chamber	*** 49166-1	Used as an air distribution chamber for the Modulator Unit. Mounting provisions for the Modulator and Cooler Units are incorporated.
	6625-592-4311	. . . Cooler, Air, Electronic Equipment	*** 47806-2	Used to filter and move air through the plenum chamber.
	6625-797-0247	. . . Adapter, Air Duct	*** 51209-1	Used to direct air flow to the Antenna Unit.
	6625-602-7918	. . Interconnecting Box	64829-1	Used to provide cable distribution for Antenna and Modulator cables.
	6625-602-8006	. . . . Cover, Test Bench	58308-1	Used as a rear board when the bench is installed for use, and as a front cover when packed for transit.
		. . Cable Assembly, RF (4 each)	65762-1	Used to connect into signal lines to measure signals and check waveshapes.
		. . Cable Assembly, RF (4 each)	59851-1	
		. . Cable Assembly, RF (4 each)	59852-1	
		. . Cable Assembly, RF (4 each)	59853-1	
	6625-592–4170	. . Cable Duct, Antenna Bench	64735-1	Used to provide cable distribution and mechanical support to the cabling.
		. . . Cable Assembly, RF (4 each)	65907-1	Used to connect into signal lines to measure signals and check waveshapes.
3–12(c)	6625-791-1021	. . Adapter, Cable breakout, Tracker (15 pin)	* 51389-1	Used to patch out Tracker books to make supply voltages available for measurement.
		. . Tool, Insert-Extract	51024-1	Tools required for installation, removal and alignment of the Antenna Unit.
		. . Tool, Insert-Extract	51024-2	

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
		. . Tool, Insert-Extract	51024-3	
		. . Tool, Crimp	51952-1	
		. . Tool, Crimp	55233-1	
		. . Pliers, Curved, Needle Nose	52305-1	
		. . Screwdriver, Straight Blade (12 in.)	66233-2	
	5120-270-3112	. . Screwdriver, Offset	52310-1	
	5120-189-2995	. . Wrench, Hex Socket, Screw Head	52311-1	
	5120-189-2994	. . Wrench, Hex Socket, Screw Head	52311-2	
	5120-189-2992	. . Wrench, Hex Socket, Screw Head	52311-4	
	5120-189-2991	. . Wrench, Hex Socket, Screw Head	52311-5	
	5120-542-2425	. . Wrench, Combination Box and Open End	66230-1	
		. . Wrench, Combination Box and Open End	66230-2	
3–9	6625-592-4295	. Test Bench Set, Computer	58469-1	Used as a work bench and packing box. It is also used to support the equipment that tests the computer group of Radar Sets AN/APN-131 or AN/APN-105.
	6625-602-8155	. . Test Bench Group, Computer	58472-1	This group is made up of the next five items.
	6625-592-4287	. . . Cover, Test Bench	58307-1	Used as a rear board when the bench is installed for use, and as a front cover when packed for transit.
		. . . . Cable Duct Assembly	64726-1	Used to provide cable distribution and mechanical support to cabling.
		. . . . . Cable Assembly, Special Purpose, Electrical, 31W6	51950-1	Used to connect into signal lines to measure signals and check waveshapes.
	6625-592-8155	. . . Test Bench Radar Maintenance	58474-1	Used as a work bench and to house the Test Set Group, Digital Computer and Test Set Group Analog Computer.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-602-8154	. . . Power Supply, Computer	58476-1	Used to supply all power to the Present Position Computer and Course Computer units of the AN/APN-131 or AN/APN-105 systems during test.
	6625-592-4280	. . Test Set Group, Digital Computer	58301-1	Used as a semi-automatic testing facility for the maintenance of the Present Position Computer units of AN/APN-131 or AN/APN-105 Radar Sets.
	6625-735-2615	. . . Cabinet, Electrical Equipment	64736-1	Used to contain, protect and provide air distribution to the next three units.
	6625-602-8147	. . . Counter, Electronic	58310-1	Used to count signal pulses from the Tracker to the Present Position Computer.
	6625-592-4276	. . . Test Set, Digital Computer	58311-1	Provides semi-automatic selection of signals to and from the Present Position Computer as "test probblems" for presentation to the electronic counter.
	6625-838-1718	. . . Simulator, Gyro Signal	58312-1	Used to simulate pitch, roll and heading angles. It also displays pitch, roll and heading readouts.
	6625-592-4274	. . Test Set Group, Analog Computer	58302-1	Used as a semi-automatic testing facility for the testing and alignment of the Course Computer, the Ground Speed Indicator and the Control Indicator of Radar Sets AN/APN-131 or AN/APN-105.
	6625-735-2616	. . . Cabinet, Electrical Equipment	64737-1	Used to contain and protect the next three units.
	6625-592-4269	. . . Indicator, Phase Angle	58315-1	Used to measure the angular position of rotating electromechanical components.
	6625-717-1327	. . . Test Adapter, Analog Computer	58317-1	Used to test and align the AN/APN-131 or AN/APN-105 Course Computer Units. System output signals are measured on an independent basis. When used with a set of system indicating instruments, the indicating instruments can be checked via substitution.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-717-1323	. . . Power Supply, Computer Test	58319-1	Used to supply power to Test Set Group, Digital Computer and Test Set Group, Analog Computer.
		. . Adapter, Connector, Style 1	*** 50002-3	Used to adapt the wiring and connectors of the Test Bench System Radar to the connector and wiring requirements of the AN/APN-105 Radar Set.
		. . Adapter, Connector, Style 2	*** 50003-2	Used to adapt the wiring and connectors of the Test Bench System Radar to the connector and wiring requirements of the AN/APN-105 Radar Set.
		. . Cable Assy, Spl Purpose Elec, 52W1	59505-1	Used to connect into signal lines to measure signals and check waveshapes.
		. . Cable Assy, Spl Purpose Elec, 52W2	59506-1	
		. . Cable Assy, Spl Purpose Elec, 52W3	59507-1	
		. . Cable Assy, Spl Purpose Elec, 52W4	59508-1	
		. . Cable Assy, Spl Purpose Elec, 52W5	59509-1	
		. . Cable Assy, Spl Purpose Elec, 52W6	59510-1	
		. . Cable Assy, Spl Purpose Elec, 52W7	66487-1	
3–10(1)		. . Plate, Synchro Nulling	** 54117-8	Used in nulling the magnetic variation module.
3–10(2)		. . Tool, Longitude Nulling	** 54117-4	Used in nulling and magnetic variation module.
3–10(3)		. . Tool, Latitude Nulling	** 54117-9	Used in nulling the magnetic variation module.
3–11(1)		. . Stand, Module Holding	** 54117-6	Used to hold Course Computer modules during zeroing operations.
3–11(2)		. . Clamp, Geartrain Locking	** 93338-1	Used to lock module geartrains.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
		. . Clamp, Geartrain Locking	** 93338-2	
		. . Clamp, Geartrain Locking	** 93338-3	
		. . Clamp, Geartrain Locking (2 each)	** 93338-4	
		. . Clamp, Geartrain Locking (2 each)	** 93338-5	
3–11(3)		. . Clamp, Geartrain Locking (2 each)	** 93338-6	
3–11(4)		. . Clamp, Geartrain Locking (5 each)	** 93338-7	
3–12(A)		. . Adapter, Cable Breakout, Position (50 pin)	68716-1	Used to patch out the plug-in cards of the Present Position Computer to make the input and output voltages available for measurement.
3–12(c)		. . Adapter, Cable Breakout, Position (34 pin) (2 each)	68708-1	Used to patch out the plug-in cards of the Present Position Computer to make the input and output voltages available for measurement.
		. . Wrench, Spline	** 13116-1	Tools required for the installation, removal and alignment of the Course Computer modules.
	5120-293-9206	. . Wrench, Hex Driver	** 93339-1	
	5120-293-9205	. . Wrench, Hex Driver	** 93339-2	
	5120-224-2508	. . Wrench, Hex Driver	** 93339-3	
	5120-293-9204	. . Wrench, Hex Driver	** 93339-4	
	5120-293-0699	. . Wrench, Hex Driver	** 93339-5	
3–13		Power Supply, D-C	93453-1	Used to provide +31V d-c to the +28V input of the Test Bench System.
	6625-373-1859	Test Set, Crystal	52087-1	Used to test the crystals in the Antenna Unit.
	6625-591-1659	Detector, Radio Frequency	51226-1	Used to align the klystron amplifiers in the Antenna Unit.

Table 3–1. Test Equipment Required for Maintenance (Cont)

Figure and Index No.	FS Number	Nomenclature	LFE Part No.	Use
	6625-553-7931	Oscilloscope	52084-1	Used for observation of waveforms.
	6625-678-5618	Preamplifier, Plug-in	52317-1	Used to increase the gain of Oscilloscope, LFE Part No. 52084-1.
	6625-593-5360	Preamplifier, Plug-in, Dual Trace	52346-1	Used to determine the time and relative pulse rates between two signal lines. Used with Oscilloscope, LFE Part No. 52084-1.
	6625-708-1955	Voltmeter, Electronic	52085-1	Used to measure a-c voltages over a wide range of frequencies and amplitudes.
	6625-518-4659	Oscillator, Audio-Radio Frequency	52088-1	Used to test the subassemblies of the Frequency Converter-Tracker over their entire frequency range.
	6625-360-2493	Voltmeter, Electronic	52086-1	Used to measure a wide range of a-c and d-c voltages.
	6625-643-1686	Multimeter	52155-1	General use.
	6625-800-5365	Frequency Meter	52156-1	Used to align the klytron amplifiers in the Antenna Unit.
		Time and Stopwatch	52176-1	Checks the tracking rate of the Frequency Converter-Trackers.
	6625-507-3766	Meter, Microwave Power	52153-1	Used to measure the transmitter power output from the Antenna Unit.
	6625-539-8868	Counter, Electronic	52325-1	Used to monitor the frequency output of the books in the Frequency Converter-Tracker.
		Video Amplifier, Plug-in	60695-1	Used to check the tracker books in Radar Set AN/APN-105 or AN/APN-131. Used with Electronic Counter, LFE Part No. 5235-1.
		Adapter Connector	27490-1	Used to adapt BNC miniature connectors to DIC miniature connectors.
		Voltmeter, Digital	87820-1	Used to measure the a-c and d-c outputs of Radar Set AN/APN-105 or AN/APN-131 Power Supply.

* Items in table 3–1 bearing a single asterisk are required to complete the installation of the Bench under which they are listed. Such items are packed for shipment with Computer Bench 58469-1.

** Items in table 3–1 bearing a double asterisk are required to complete the installation of the Bench under which they are listed. Such items are packed for shipment with Antenna Bench 58470-1.

*** Items in table 3–1 bearing a triple asterisk are required to complete the installation of the Bench under which they are listed. Such items are packed for shipment with Mock-up Bench 58471-1.

Table 3–2. Tools Required for Maintenance

527AT-G-748	Screwdriver, Torque, 37 oz.-in.	Used to torque the card connector

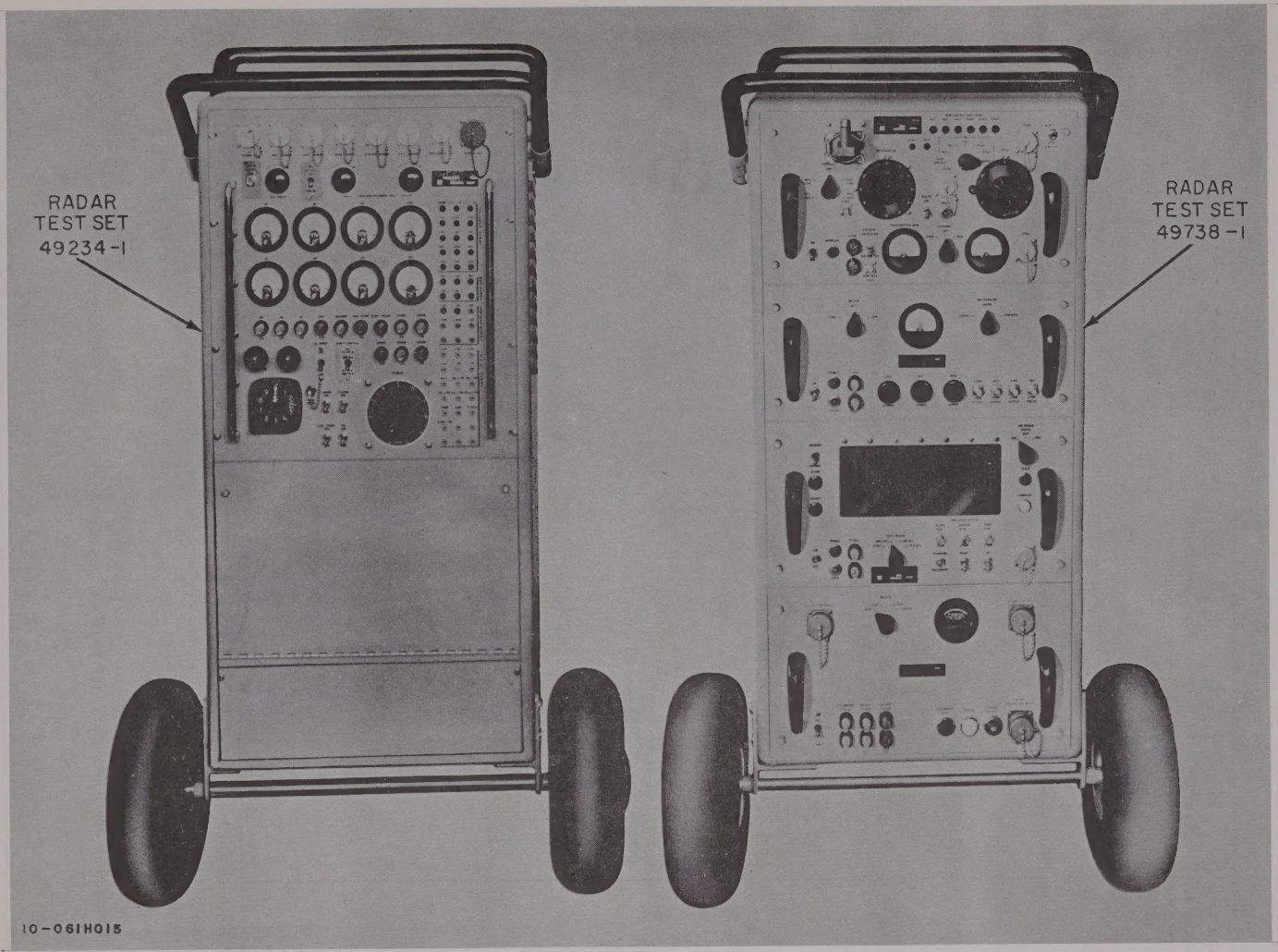


Figure 3–1. Test Set, Radar AN/GPM-24 (XY-2) Part No. 49665-1

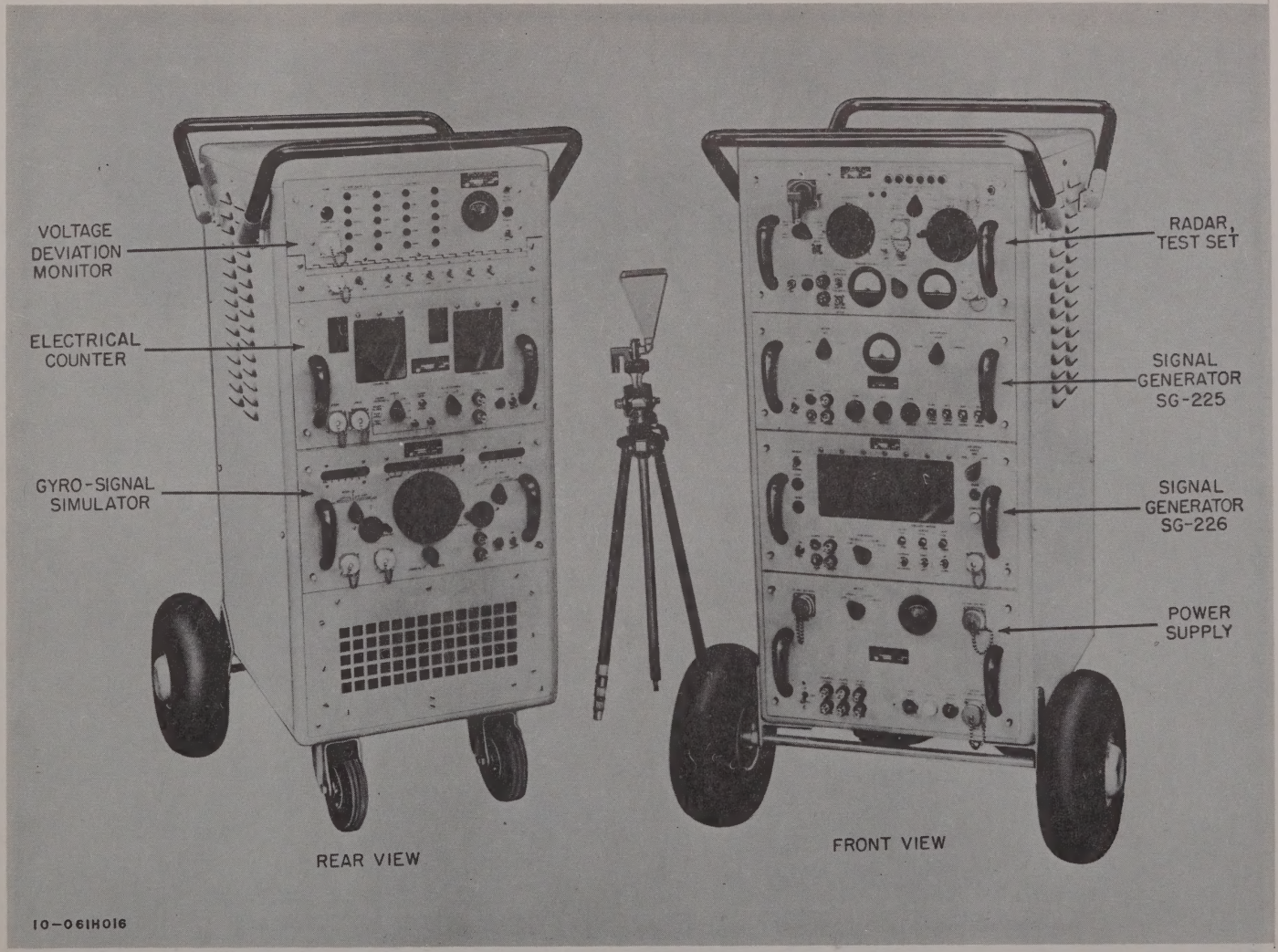


Figure 3–2. Test Set, Radar, Part No. 49738-1, Front and Rear View

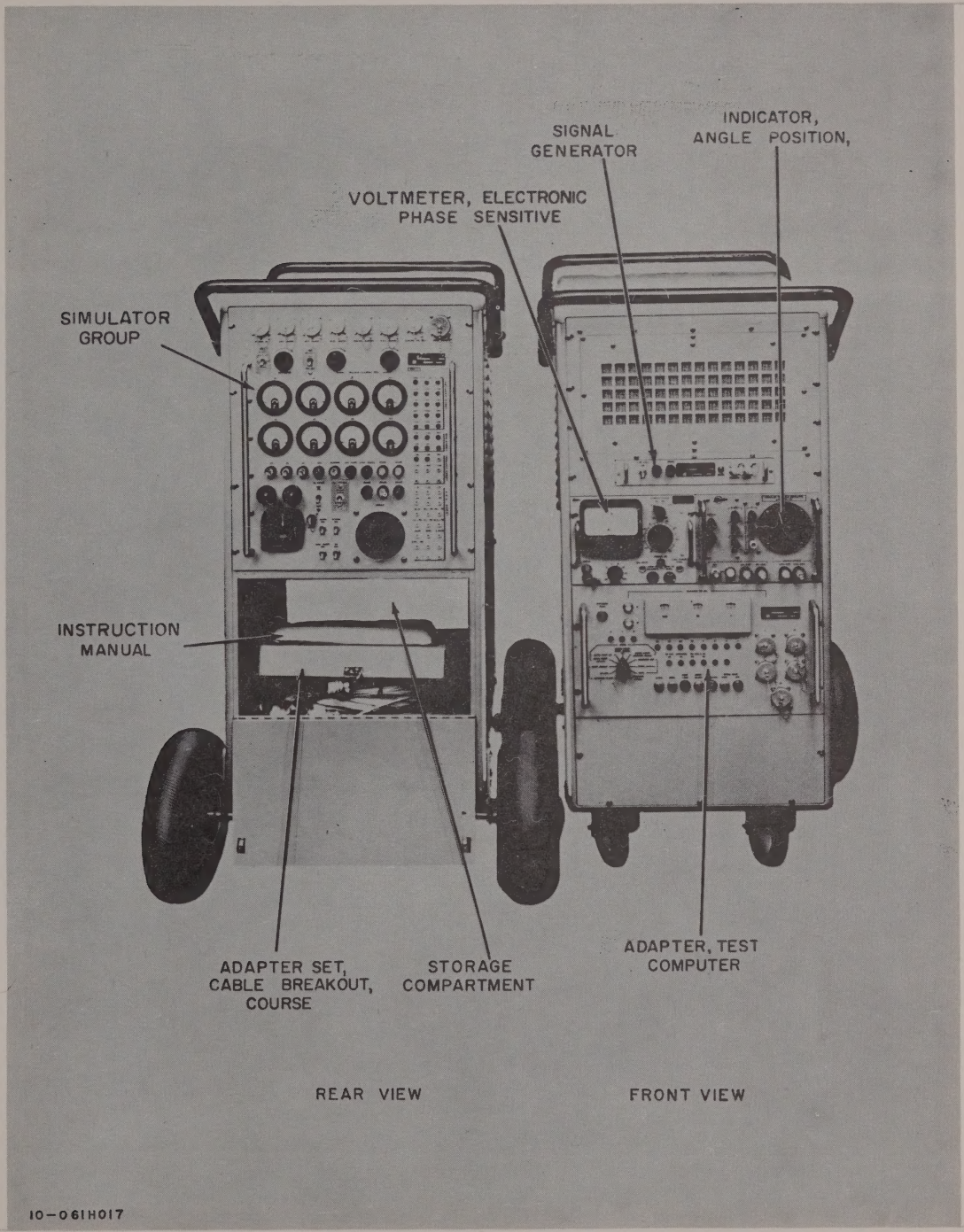


Figure 3–3. Test Set, Radar, Part No. 49234-1, Front and Rear View

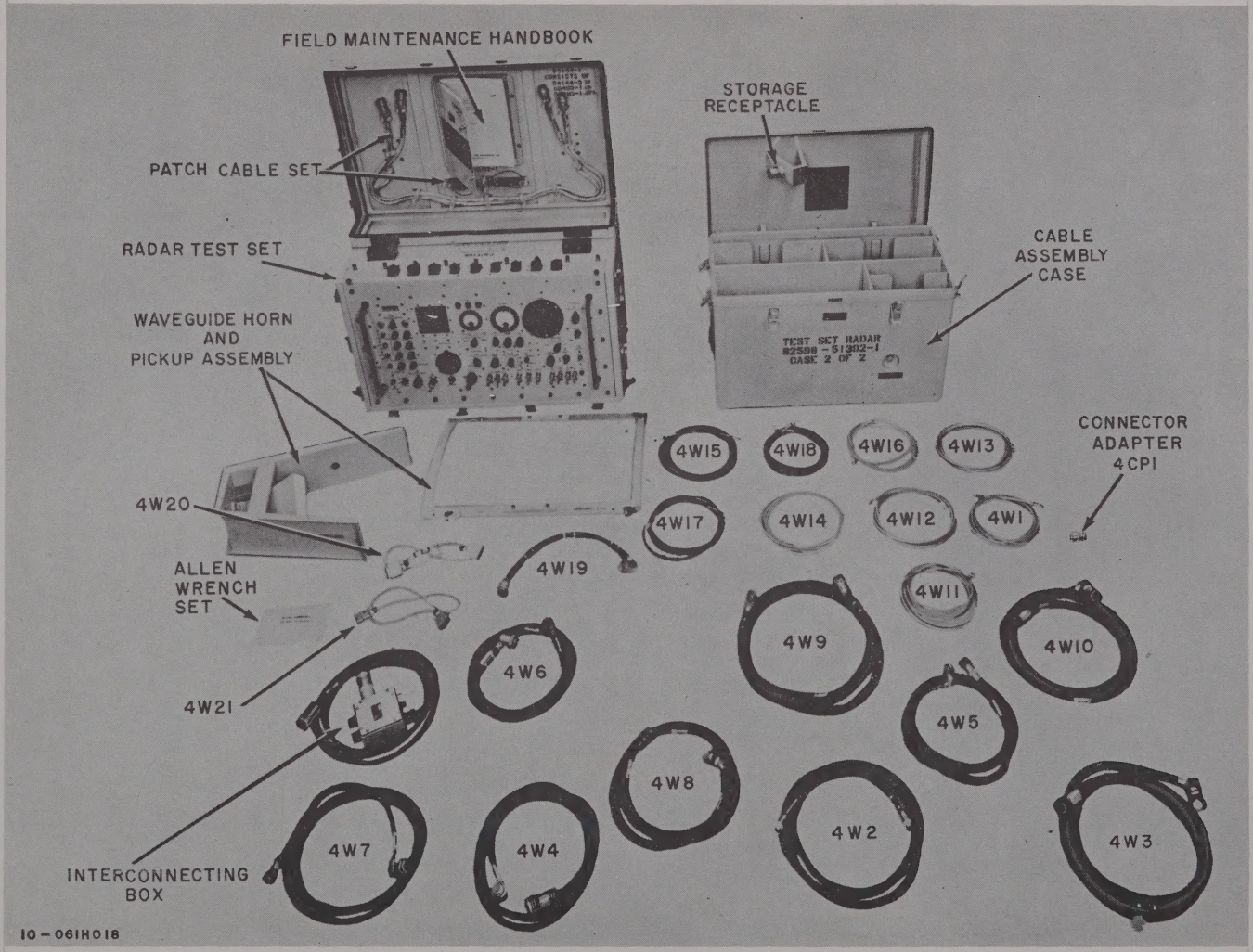


Figure 3–4. Test Set, Radar, Part No. 51392-1

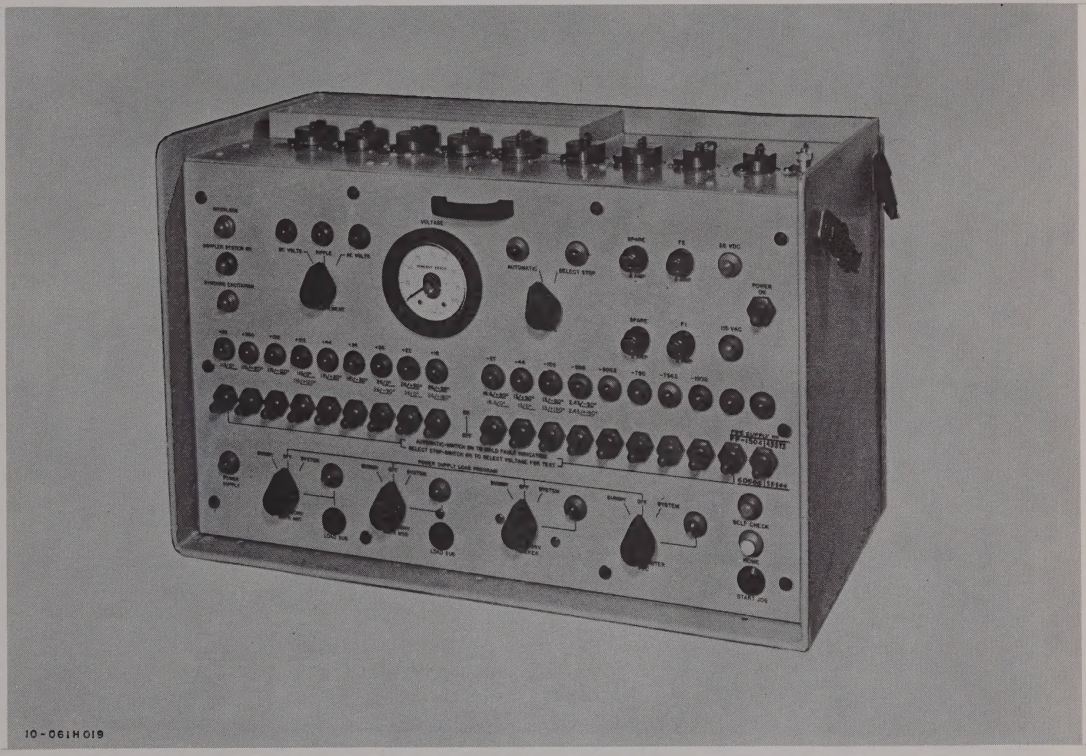


Figure 3–5. Monitor, Voltage Deviation, Part No. 51248-1

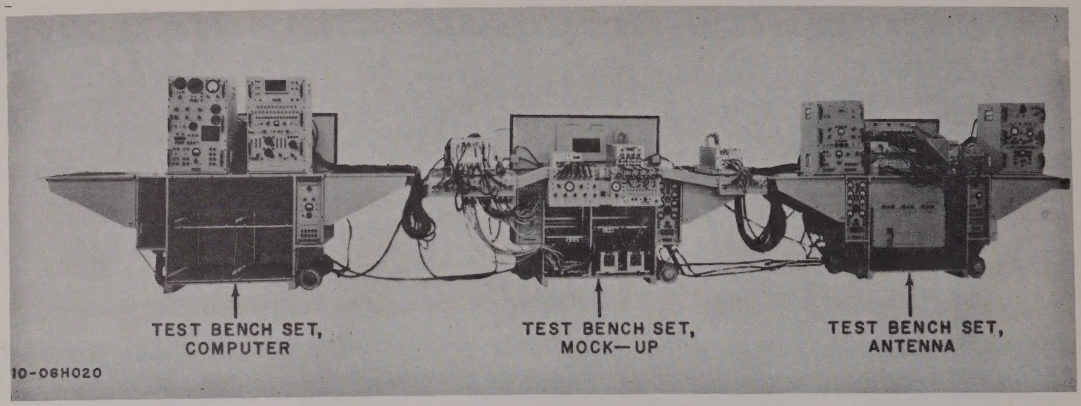


Figure 3–6. Test Bench System, Radar, Part No. 58461-1

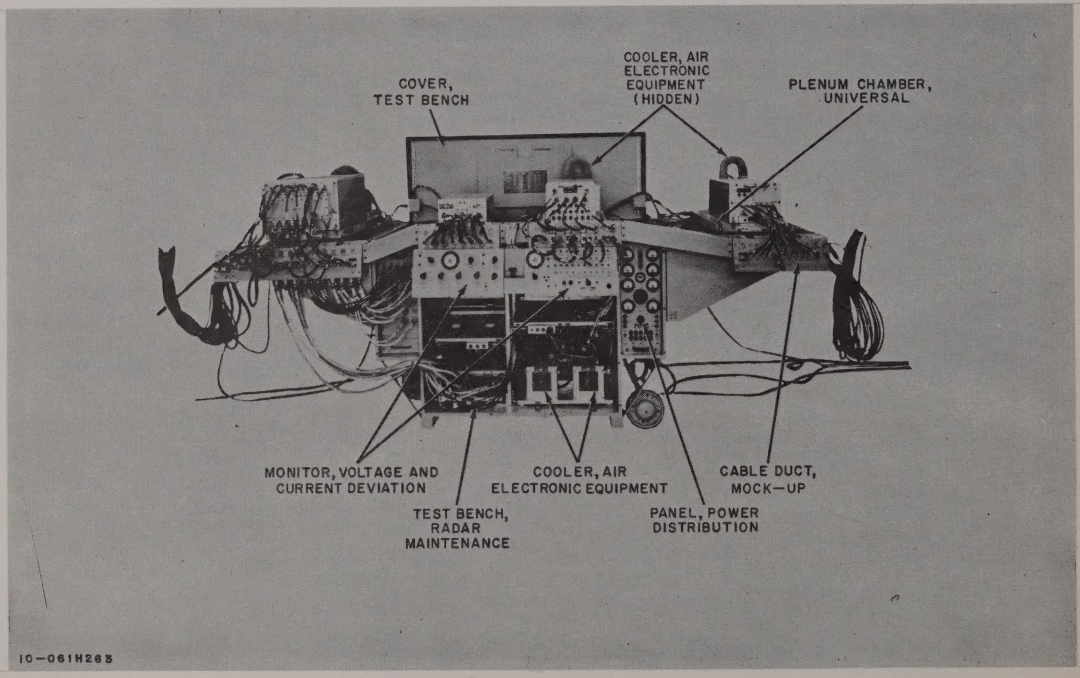


Figure 3–7. Test Bench Set, Mock-up, Part No. 58471-1

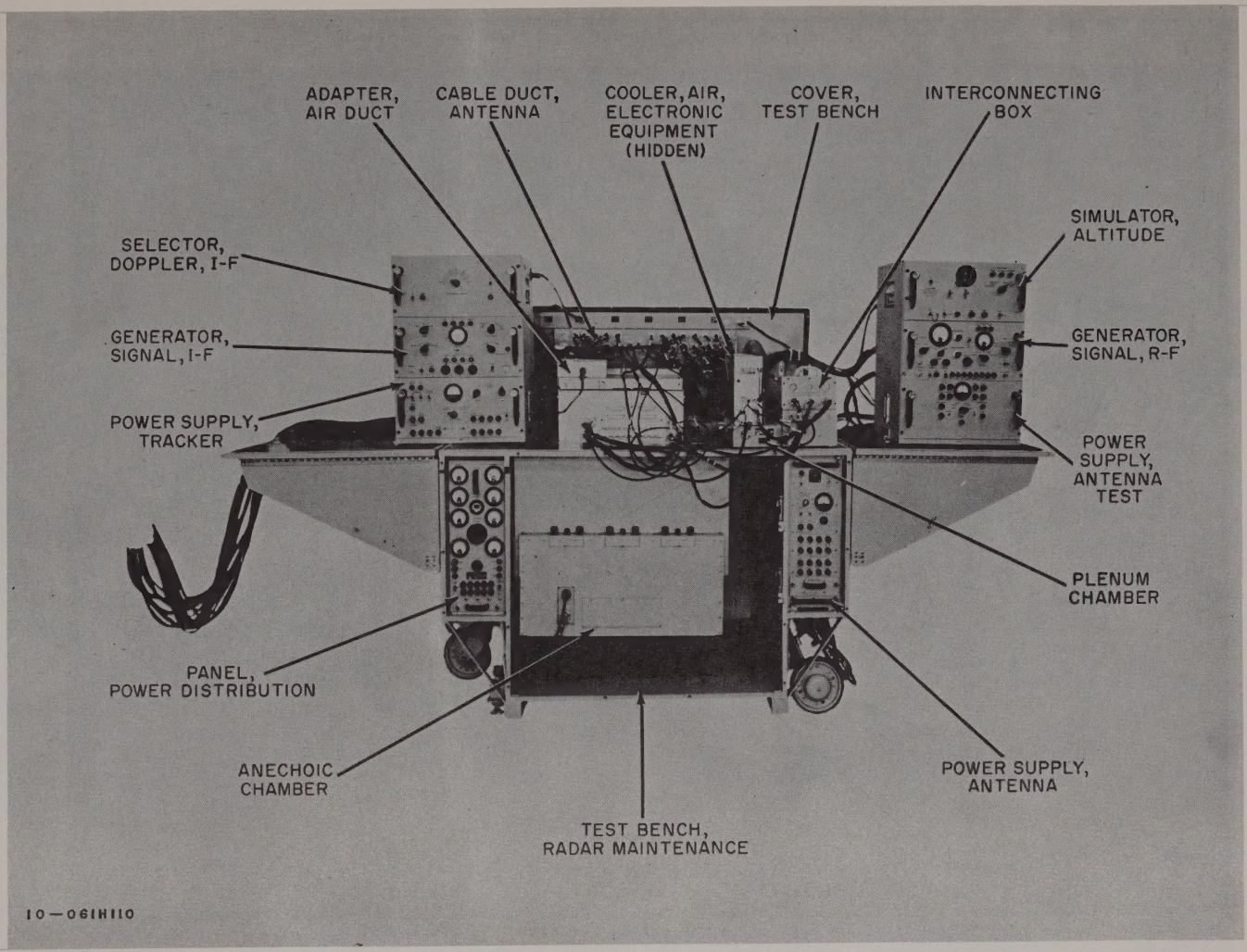


Figure 3–8. Test Bench Set, Antenna, Part No. 58470-1

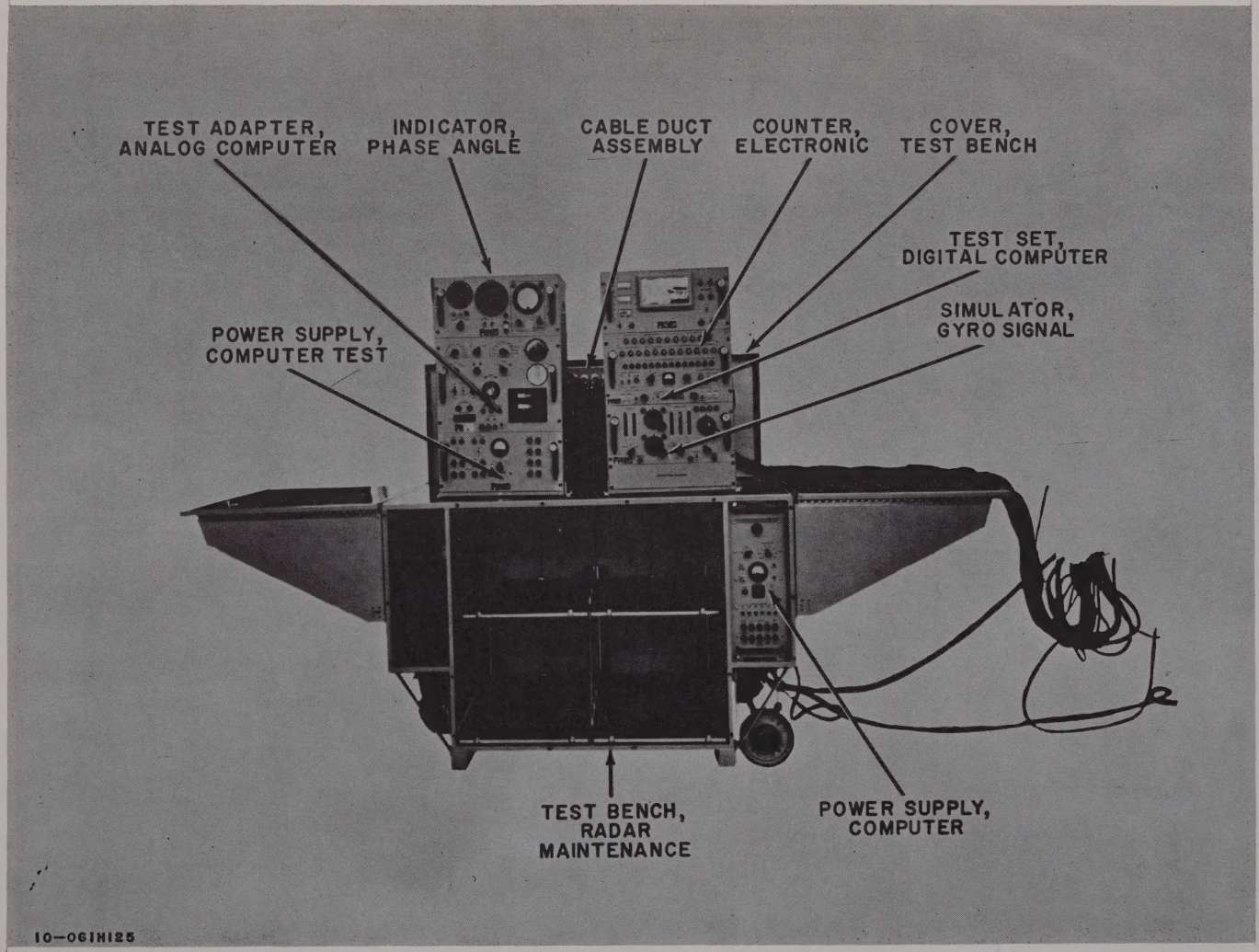
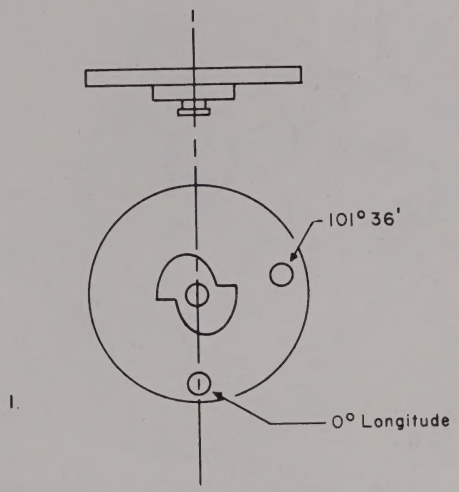
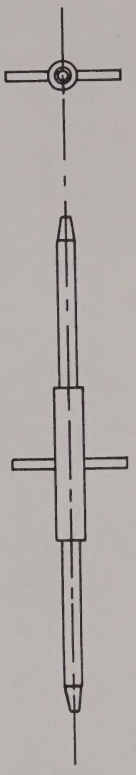
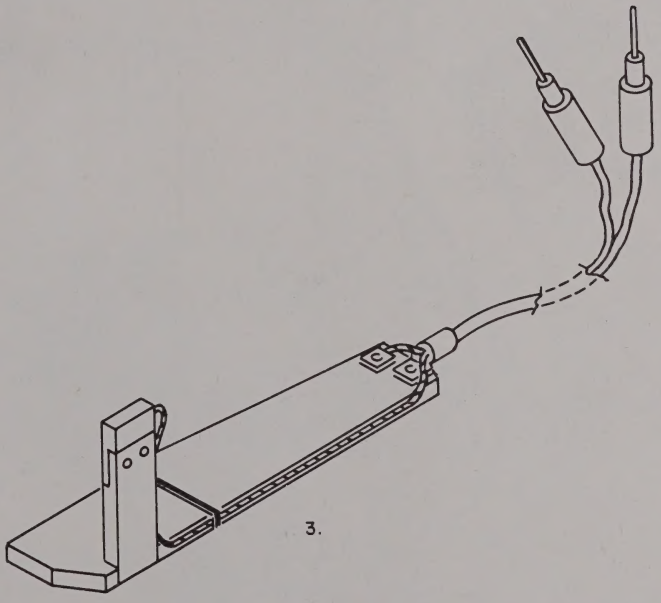


Figure 3-9. Test Bench Set, Computer, Part No. 58469-1



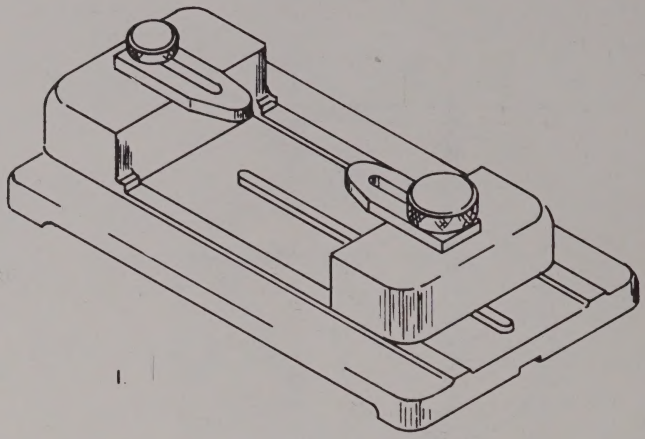




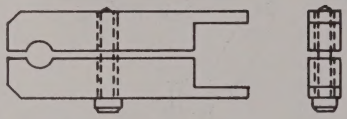
1 SYNCHRO NULLING PLATE
2 LONGITUDE NULLING TOOL
3 LATITUDE NULLING TOOL

10-061X264

Figure 3-10. Nulling Tools, Magnetic Variation Cam



1.



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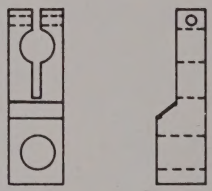

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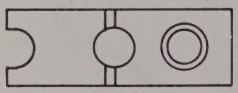

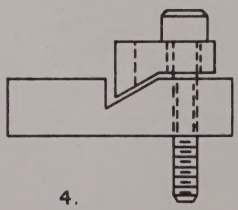

4.

1 MODULE HOLDING STAND
2 GEARTRAIN LOCKING CLAMP, LFE 93338-1 TO -5
3 GEARTRAIN LOCKING CLAMP, LFE 93338-6
4 GEARTRAIN LOCKING CLAMP, LFE 93338-7

10-061X265

Figure 3-11. Module Holding Stand and Geartrain Locking Clamps

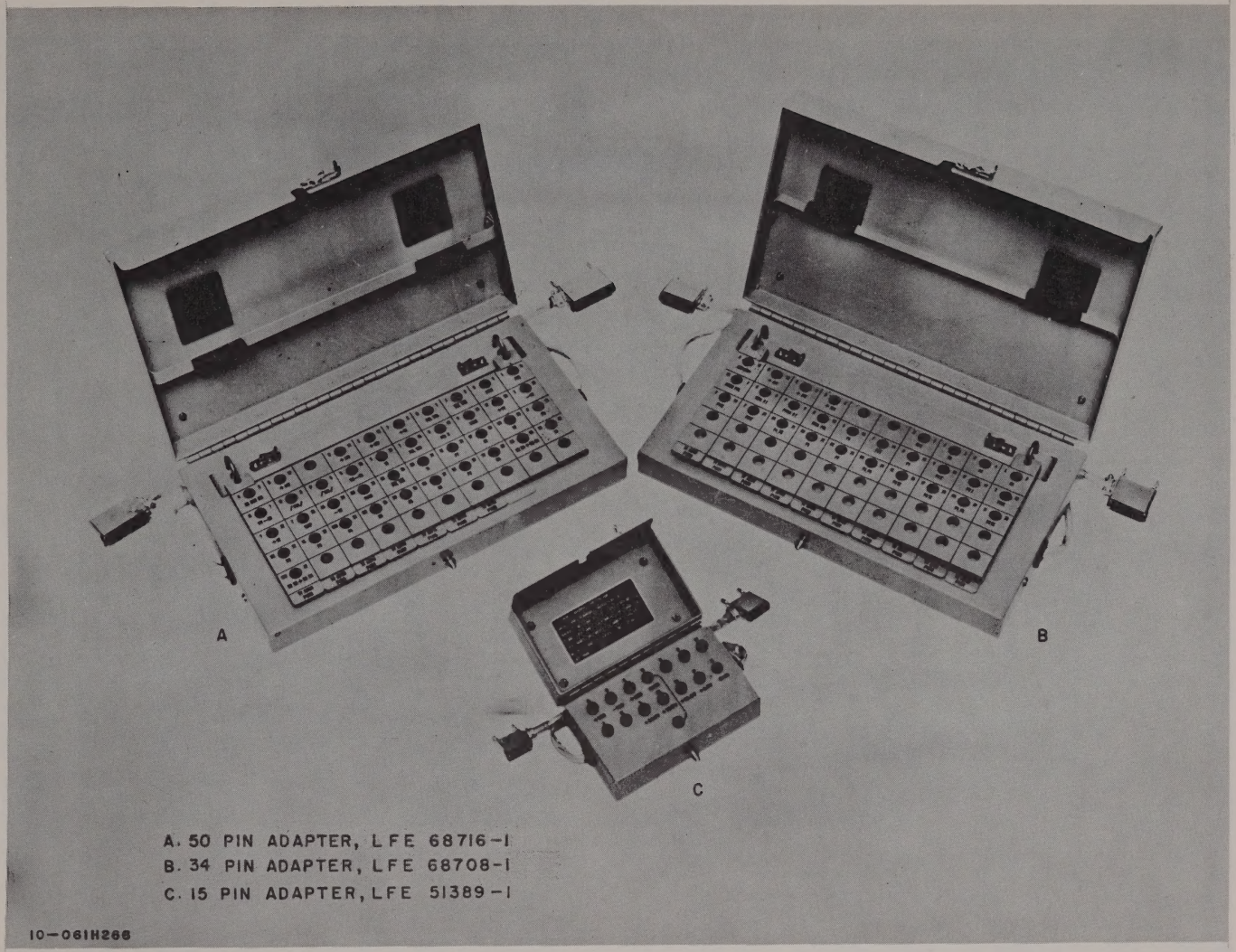

Figure 3–12. Adapter, Cable Breakout

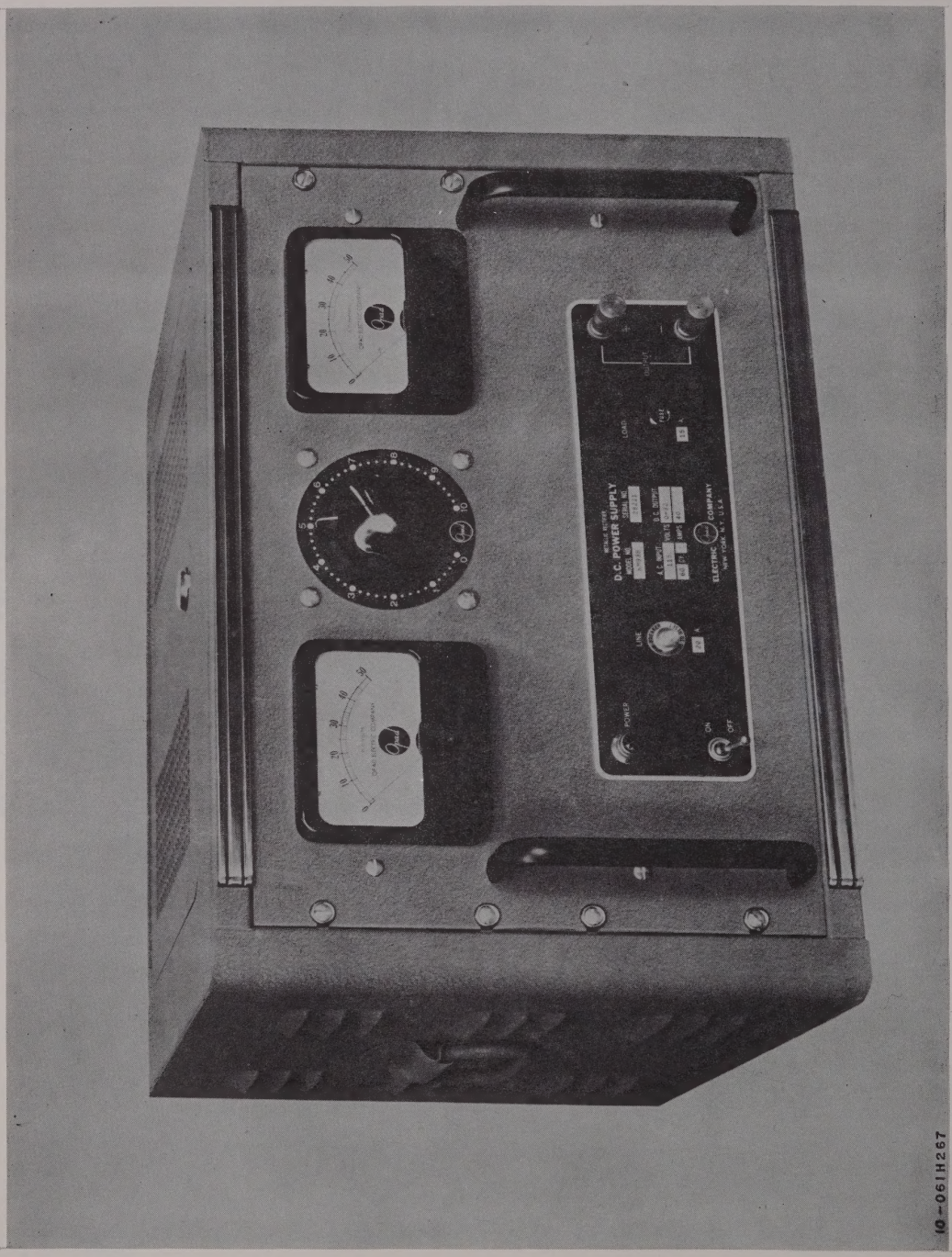

Figure 3-13. Power Supply, D-C, Part No. 93453-1

SECTION IV
THEORY OF OPERATION

LIST OF ILLUSTRATIONS

Figure No.	*Title*	*Page*
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4–1. TEST POINTS.

4–2. MAJOR TEST POINTS.

4–3. Major test points are indicated on the diagrams and referred to in the text of the sections on maintenance (Sections VI through XIV). They appear on the diagrams as star-encircled arabic numerals, and always point to an indentified unit or subassembly connector (jack or plug). Major test points are assigned numbers in the order of presentation in the sections on unit maintenance (Sections VII through XIV). These test point numbers are repeated where applicable in Section VI, Check-Out or Analysis.

4–4. MINOR TEST POINTS.

4–5. Secondary and minor test points are not indicated in the diagrams of this handbook because the maintenance procedures herein require no test within subassemblies.

4–6. THEORY OF OPERATION OF RADAR SET AN/APN-105.

4–7. GENERAL.

4–8. This section contains the general theory of operation of Radar Set AN/APN-105 doppler navigator. The system principles of operation are discussed, and the functions of each of the units of the doppler navigator are covered. A more detailed analysis of each unit is contained in the detailed theory of operation portion of each unit maintenance section.

4–9. GLOSSARY.

4–10. A glossary of terms used most frequently in Section IV is given below. The remaining terms used in this section are explained in the text.

f_1 = side beam doppler shift

f_2 = fore beam doppler shift

f_3 = aft beam doppler shift

V_{xa} or $f_2 - f_3$ = forward velocity (with respect to aircraft axis)

V_{ya} or $2f_1 - f_2 - f_3$ = side velocity (with respect to aircraft axis)

V_{za} or $f_2 + f_3$ = vertical velocity (with respect to aircraft axis)

V_x = horizontal forward velocity

V_y = horizontal side velocity

V_z = true vertical velocity

$V\underset{x}{+}$ = positive pulse contribution to V_x

$V\underset{x}{-}$ = negative pulse contribution to V_x

$V\underset{y}{+}$ = positive pulse contribution to V_y

$V\underset{y}{-}$ = negative pulse contribution to V_y

$V\underset{z}{+}$ = positive pulse contribution to V_z

$V\underset{z}{-}$ = negative pulse contribution to V_z

$V_{n\text{-}s}$ = ground speed north or south

$V_{e\text{-}w}$ = ground speed east or west

$V_{n\text{-}s}^{+}$ = positive pulse contribution to $V_{n\text{-}s}$ (north going)

$V_{n\text{-}s}^{-}$ = negative pulse contribution to $V_{n\text{-}s}$ (south going)

$V_{e\text{-}w}^{+}$ = positive pulse contribution to $V_{e\text{-}w}$ (east going)

$V_{e\text{-}w}^{-}$ = negative pulse contribution to $V_{e\text{-}w}$ (west going)

P = pitch

R = roll

A_n = air speed north

A_s = air speed south

A_e = air speed east

A_w = air speed west

W_n = wind velocity north

W_s = wind velocity south

W_e = wind velocity east

W_w = wind velocity west

lat = latitude

Δ lat = change in latitude

long. = longitude

Δ long. = change in longitude

PP = present position

dt = destination

LA = destination latitude minus present position latitude

LON = destination longitude minus present position longitude

CA = course angle

GT = ground track

DA = drift angle

GS = ground speed

dist = distance

SR = short range

LR = long range

sin = sine

cos = cosine

tan = tangent

sec = secant

4–11. SYSTEM PRINCIPLES OF OPERATION.

4-12. GENERAL. Radar Set AN/APN-105 doppler nagivator measures the velocity of the aircraft by use of the doppler principle. Energy is radiated towards the ground from the aircraft, and the doppler shift of the reflected echoes is determined by the aircraft velocity.

4–13. If the source of electromagnetic energy in the aircraft is moving relative to a reflecting surface, the frequency of the reflected signal is shifted by an amount proportional to the vector component of aircraft velocity measured along the beam axis. The frequency of the reflected signal, as measured by a receiver associated with the transmitter, is shifted twice this amount. The additional doppler shift is introduced by the relative movement between the aircraft receiver and the reflecting surface. The total doppler shift f_d is determined by the formula: $f_d = 61v/\lambda$, where

f_d = doppler shift in cycles per second

v = vector component of aircraft movement along beam axis in feet per second

λ = transmitted wavelength in centimeters.

4–14. The transmitted frequency of the doppler navigator is 9799 mc, which is a wavelength of 3.06 centimeters. Substituting 3.06 for λ in the above formula,

$$f_d = \frac{61v}{3.06}$$

or $$f_d = 20v$$

Thus, every foot per second of the vector component of aircraft velocity which is in the direction of the transmission results in 20 cycles of doppler shift per second. Eliminating the time factor from both sides of the equation, each foot of aircraft movement over any time produces 20 cycles of doppler shift over that same time. Thus, one cycle of f_d represents 1/20 foot, or 0.6 inch, of aircraft movement. This figure is for the vector component of aircraft velocity in the direction of the transmitted beam.

4–15. When the aircraft is flying horizontal, no actual change of vertical distance between aircraft and ground need occur. Doppler shift, however, is obtained in proportion to that vector component of aircraft movement which is in the direction of the radiated beam. This shift occurs because there is relative motion between the aircraft and that portion of the ground illuminated by the fore (and aft) beams. For every point on the reflecting surface of the ground, aircraft movement causes the time between successive arrivals of radiated energy cycles at the ground point to differ from the time normally intervening between these cycles. Time between cycles of radiated signal determines its frequency.

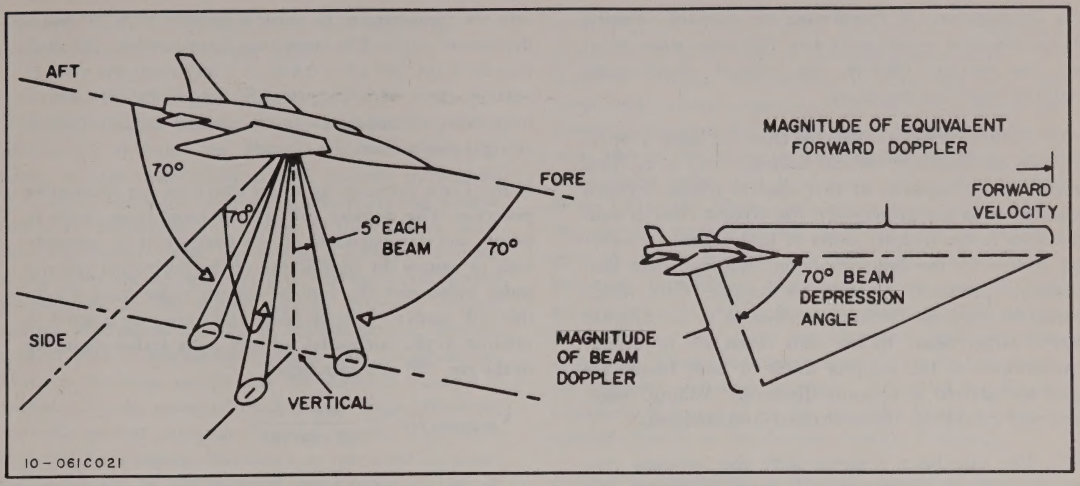


Figure 4–1. Sketch of Beam Orientation

4–16. For an aircraft flying horizontally, the vector component of aircraft velocity between aircraft and reflecting surface along the axis of a beam depressed 70° is:

Vector component along beam (velocity) = forward velocity × cos 70°

as shown in figure 4–1.

4–17. The terms "opening" and "closing" refer to the direction of the vector component of aircraft velocity measured along the beam axis. The doppler shifts obtained from the three beams are designated f_1 (side beam), f_2 (fore beam) and f_3 (aft beam). If the velocity is closing (as for the fore beam in level flight) the doppler-shifted echo will be higher in frequency than the transmitted frequency; if the velocity is opening (as for the aft beam in level flight) the doppler-shifted echo will be lower in frequency.

4–18. Forward velocity along the axis intersecting the nose and tail of the aircraft, retaining the original doppler significance (1 cycle of doppler shift = 0.6 inch), is represented by the formula:

$$\text{forward velocity} = \frac{f_2 - f_3}{2 \cos 70°}$$

The doppler shift from the aft beam is subtracted from the doppler shift of the fore beam. Motion along two other mutually perpendicular aircraft coordinates (side and vertical), retaining the original doppler significance, is represented by the formula:

$$\text{side velocity} = \frac{2f_1 - f_2 - f_3}{2 \cos 70°}$$

$$\text{vertical velocity} = \frac{f_2 + f_3}{2 \sin 70°}$$

It should be noted at this point that these specific formulas are for illustrative purposes. The system does not actually perform all the mathematical operations that are discussed here. The reasons for this will be brought out in paragraphs 4–24 through 4–27.

4–19. Forward, side and vertical velocities are referred to aircraft coordinates and not to horizontal and vertical coordinates (unless the aircraft attitude is horizontal). For simplicity of the following discussion, the aircraft is assumed to be oriented horizontally, thus referring the beam depression angles to the horizontal.

4–20. In the preceding formulas, the algebraic combinations of doppler shifts from the three beams serve to separate the doppler shift of each beam into the horizontal and vertical components contributing to that doppler shift. The doppler shift from each beam indicates opening or closing velocity along the respective beam axis. These doppler shifts could be attributed to horizontal motion, vertical motion, or both.

4–21. Horizontal forward velocity is separated from the doppler shifts resulting from contributions of both horizontal and vertical velocity by the formula: forward velocity = $f_2 - f_3$. The doppler shift obtained from the aft beam is subtracted from the doppler shift obtained from the fore beam. Contributions from vertical velocity to both beam doppler shifts are equal and shifted in the same direction and thus cancel out. Contributions from horizontal velocity to beam doppler shifts are equal and shifted in opposite directions. The subtraction in the formula becomes $+ f_2 - (-f_3)$, resulting in a term whose frequency is twice the horizontal contribution to the doppler shift of either beam. To illustrate the dop-

pler combination: if there were no forward velocity, the combination would yield zero frequency since whatever the vertical velocity, the vertical contributions would be equal and cancel out.

4–22. Vertical velocity is selected from the beam doppler shifts by the formula: vertical velocity — $f_2 + f_3$. This process is the opposite of that used to obtain forward velocity. As in paragraph 4–21, the vertical velocity contributions to the doppler shifts of both beams are equal and shifted in the same direction. Adding these contributions produced a combined doppler shift which represents twice the vertical contribution to the doppler shift of either beam. By the same token, the horizontal contributions to the doppler shifts of both beams are equal and shifted in opposite directions. Adding, therefore, will cancel out the horizontal contributions.

4–23. The side beam doppler shift also contains contributions from horizontal and vertical velocity. To derive the side velocity, the vertical component of velocity is subtracted from the side beam doppler shift (we have already obtained the vertical component from the formula $f_2 + f_3$). The side beam doppler (f_1) is multiplied by two to compensate for the effective doubling of the vertical component doppler, as explained in paragraph 4–22 above. Thus, the formula for side velocity becomes:

$$2f_1 - (f_2 + f_3) \quad \text{or} \quad 2f_1 - f_2 - f_3 \quad .$$

4–24. Division by two in each of the above formulas for forward, side and vertical velocity compensates for the fact that the algebraic addition of doppler returns effectively doubles the frequency of the original single beam doppler shift. Division by cos 70° for the forward (and side) velocity formulas compensates for the disadvantage introduced by the 70° beam depression angle into the measurement of aircraft forward (and side) velocity. (Note again, however, that the system does not actually perform division by 2 or by cos 70°, but lumps all constants together and accomplishes the necessary total count-down in the Present Position Computer.) The correction introduced by the division by 2 cos 70° ($2 \times 0.342 = 0.684$) alters these terms to doppler shifts that would have been obtained were transmitted beams projected directly forward and to the right of the aircraft. Division by 0.684 would thus restore the distance-moved significance of each cycle of doppler shift, now representing forward and side velocity, to the original 0.6 inch per cycle.

4–25. Similarly, for vertical velocity, division by 2 sin. 70° would be necessary to retain the 0.6 inch per cycle doppler shift significance. Division by two again compensates for the combining of doppler returns. Division by sin. 70° compensates for the disadvantage introduced into the measurement of vertical velocity by a 70° beam depression angle. The correction introduced by the division by 2 sin. 70° ($2 \times 0.940 = 1.88$) alters the vertical velocity term to a doppler-shift frequency that would have been obtained were a transmitted beam projected straight down from the aircraft.

4–26. These formulas as set up above are for illustrative purposes. The doppler shift is converted from cycles to pulses and for purposes of computation it is necessary only to equate the significance of the horizontal velocity pulse trains with the vertical velocity pulse train. To do this the vertical velocity pulse train must be altered in relation to the horizontal velocity pulse trains according to the tan. 70° as shown below.

$$V_{\text{HORIZONTAL}} = \frac{f_2 - f_3}{2 \cos 70°}$$

$$V_{\text{VERTICAL}} = \frac{f_2 + f_3}{2 \sin. 70°}$$

$$\frac{V_{\text{HORIZONTAL}}}{V_{\text{VERTICAL}}} = \frac{\dfrac{f_2 - f_3}{2 \cos 70°}}{\dfrac{f_2 + f_3}{2 \sin. 70°}} = \frac{f_2 - f_3}{2 \cos 70°} \times \frac{2 \sin. 70°}{f_2 + f_3}$$

$$\frac{V_{\text{HORIZONTAL}}}{V_{\text{VERTICAL}}} = \frac{f_2 - f_3}{f_2 + f_3} \times \frac{\sin. 70°}{\cos 70°} = \frac{f_2 - f_3}{f_2 + f_3} \tan. 70°$$

It can be seen that the horizontal doppler shift to the vertical doppler shift will equal the $f_2 - f_3$ frequency shift to the $f_2 + f_3$ shift only when the frequency shift ratio is multiplied by the tan. 70°. This could be done by multiplying $f_2 - f_3$ by tan. 70° or dividing $f_2 + f_3$ by tan. 70°. (See paragraphs 4–86 and 4–87.) This computation is performed by the system, at the input of the Present Position Computer. After the same relative pulse significance to distance moved, for all three pulse trains, is obtained, the trains may then be counted down equally as desired, to obtain the final distance significance for each pulse at the output of the Present Position Computer.

4–27. The changing significance of each pulse train may be followed throughout the Present Position Computer. Each forward and side velocity pulse at the input to the Present Position Computer signifies 0.6/2 cos 70° inches moved ($0.6/2 \times 0.342 = 0.877$ inch). Each vertical pulse at the input to the Present Position Computer signifies 0.6/2 sin. 70° inches moved ($0.6/21.88 = 0.319$ inch). Each of the three pulse trains is altered in the

roll-pitch resolution (initial calibration multipliers) to a significance of 7.1 inches per pulse.

4–28. NAVIGATIONAL COMPUTATION AND ACCURACY. Digital techniques are employed to process information through the Present Position Computer which, in turn controls the present position indications of Control Indicator through synchros in the Course Computer. Information is carried in the form of pulse rates and binary codes containing a sufficient number of digits for the desired accuracy. Accurately controlled computation in the digital section provides present position indications accurate to 0.3 per cent of distance traveled plus 1 minute in latitude. The longitude accuracy is the same except that the distance traveled is multiplied by the secant of the latitude. These tolerances are with perfect compass heading inputs. The error produced by compass inaccuracy in per cent is equal to the tangent of the compass error angle $\times$ 100. A compass error of 0.5°, for example, is equal to compass inaccuracy of 0.87%. Consequently, on a 100-mile flight a compass heading error of 0.5° would result in an across-course error of 0.87 mile. (See table 1–2.)

4–29. The course angle and distance-to-destination indications are computed in the Course Computer by analog techniques. Analog computations by shaft rotations and electrical additions are not so accurate as the digital computations done in the Present Position Computer. Since the present position indication, taken from the output of the digital section, is always within 0.4 per cent accuracy, the destination will always be reached within the same range of accuracy. However, since course angle may be slightly less accurate, the flight may follow somewhat of a deviation from the optimum great-circle route. Assume, for example, that the course angle is computed with an error of 2° left. The pilot will deviate 2° to the left of the ideal course. However, the present position will still be accurate to 0.4 per cent of distance travelled whether the indicated course is correct or not. As the aircraft, nearing the destination, bears to the left of the ideal course, the course angle indication will shift, indicating that the destination is more to the right. The result will be an actual course slightly to the left of the ideal one, but ending at the desired destination with an error determined only by the accuracy of the present position computation. The effect of the course computation error is only to lengthen the total flight a small amount, owing to the curved route followed. The effect of errors in the analog distance-to-destination computation is merely to give an indication of distance-to-go that is off by a small fixed percentage. But as distance-to-go decreases, the actual number of miles represented by the fixed percentage error also decreases.

4–30. POLAR OPERATION. Two factors complicate navigation in polar regions (latitude greater than 75°): magnetic compass information is unreliable near the poles, and position reporting in terms of longitude becomes cumbersome because of the convergence of longitude lines at the poles. In polar flights, therefore, both the compass system and the doppler system must operate in the DG mode. When the compass is in the DG mode, the magnetic slaving must be removed from the heading gyro so that it operates as a free gyro, oriented to 0° longitude (Greenwich Meridian) on the equator. The gyro, when operating in the polar mode, must be slewed in order to orient it to the transverse grids of polar operation. When the doppler system is in the DG mode, the magnetic variation correction circuit in the Course Computer is bypassed so that the gyro heading input is applied directly to the Present Position Computer.

4–31. The orientation of the free gyro to 0° longitude on the earth's equator causes the present position reporting system to be compatible with a new grid of latitude and longitude lines, configured similarly to the true ones, but with poles located at 0° and 180° true longitude on the equator. (See figure 4–2.) In the polar regions the latitude and longitude grid lines are widely spaced while longitude bunching occurs at the true equator, outside the range of polar navigation. Maps prepared with the new grids of polar coordinates must be used instead of the conventional ones.

4–32. THEORY OF OPERATION OF FREQUENCY CONVERTER-TRANSMITTER 58002.

4–33. The primary function of the Modulator Unit is to determine the transmit-receive cycle of the Antenna Unit. The Modulator Unit accomplishes this by providing two gating signals to the Antenna Unit, one for the purpose of enabling the transmitter and the other for enabling the receiver. In addition, the Modulator Unit generates reference signals for use elsewhere in the system. (See figure 4–3.)

4–34. The Antenna Unit employs the interrupted c-w method of signal transmission and echo reception. The transmitter radiates energy during designated intervals, and reception circuits are enabled during alternate noncoincident intervals. The length of the signal path from aircraft to ground and back again and, hence, the round-trip transit time, varies proportionally with altitude. The length of the transmit-receive intervals are varied according to aircraft altitude by the Modulator Unit.

4–35. The Modulator Unit consists of a barometric pressure switch (baroswitch), a gate generator, a frequency generator, and an r-f amplifier. The Modulator Unit determines the transmit-receive cycle by the combined action of the baroswitch, the gate generator, and

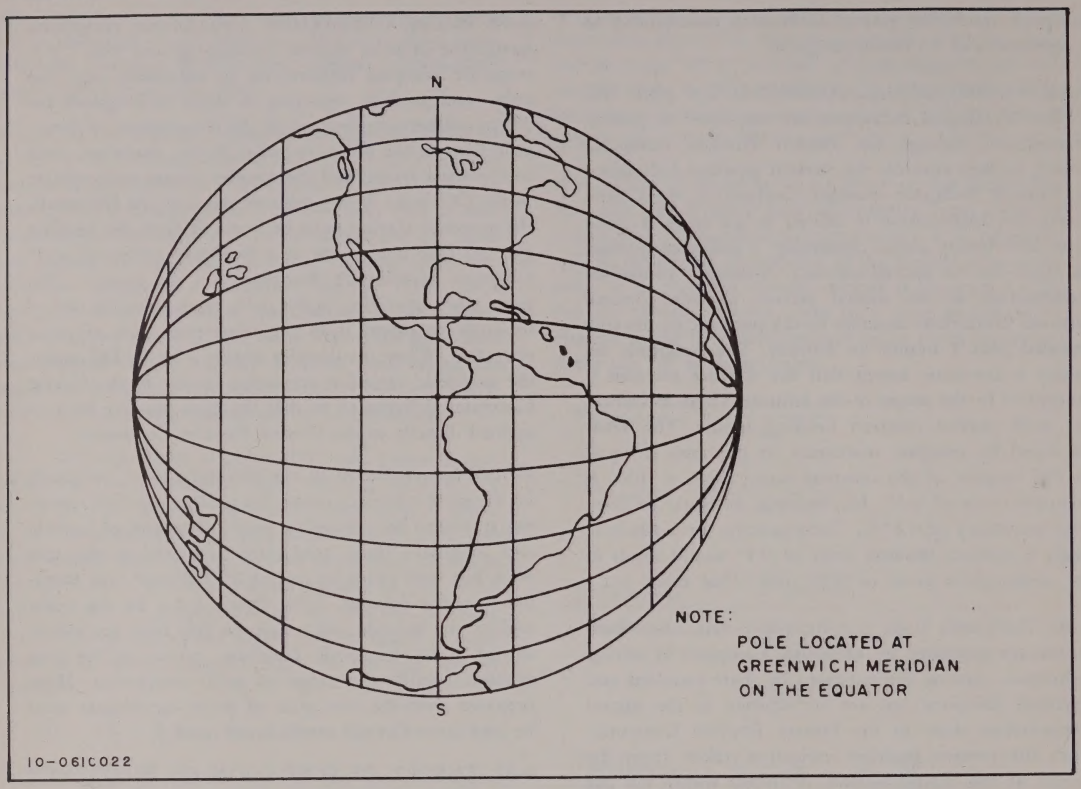
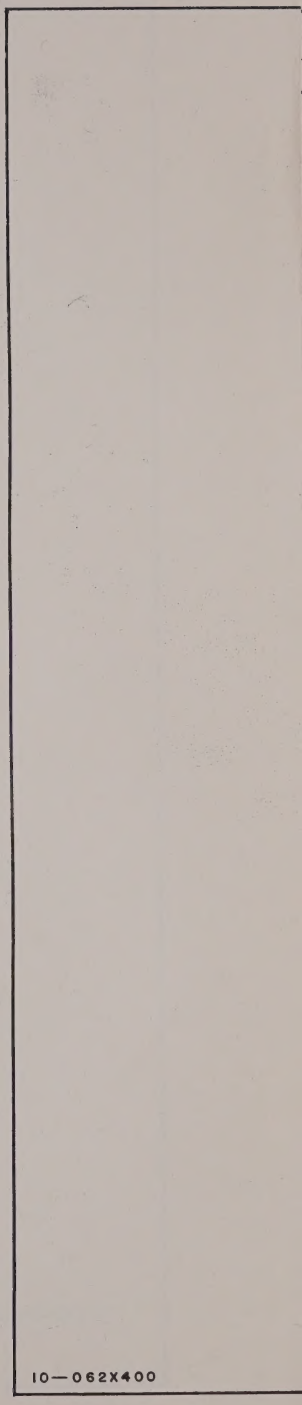


Figure 4–2. Transverse Coordinate Grid System

the frequency generator. The gate generator, in conjunction with the baroswitch, supplies the frequency generator with transmitter and receiver gates. The "on-off" timing of these gates is controlled by the gate generator. The gates alternately enable r-f signals at the output of the frequency generator which, in turn, alternately enables the transmitter and the receiver.

4–36. At altitudes between 2000 and 70,000 feet, a fraction of a microsecond dead time is allowed between "transmitter on" and "receiver on" intervals. This dead time insures that the receiver will not be on while microwave energy is being transmitted. If the transmitter and receiver were to be on simultaneously, the i-f amplifiers would become saturated with the r-f signal during the overlap period. This would block the i-f amplifiers and until they "recovered", any weak signal return would be lost. When the aircraft is flying near the ground (below 2000 feet), the round-trip transit time is extremely short. Echoes under these conditions cease almost immediately after the end of the "transmitter on" interval. At the lowest altitude step (0 to 2000 feet) dead time separation between the end of the "transmitter on" interval and the beginning of the "receiver on" interval is eliminated and the intervals are made to overlap by 0.6 microsecond (see figure 4–4). Thus no echoes are lost in the lowest altitude step during the period otherwise devoted to dead time preceding the "receiver on" interval. The stronger signal return at the lower altitudes compensates somewhat for signal losses due to saturation of the i-f amplifiers.

4–37. The baroswitch senses the altitude of the aircraft in three altitude steps: low, intermediate, and high. In the low-altitude step (0 to 2000 feet), the baroswitch initiates the required 4-microsecond transmit-receive interval and the 0.6-microsecond transmit-receive overlap condition within the gate generator. In the intermediate-altitude step (2000 to 35,000 feet), the baroswitch allows the gate generator to initiate sequential transmit-receive intervals of 14, 18, and 24 microseconds and the 0.2 microsecond dead time condition so that echo reception is assured at all altitudes between 2000 and 35,000 feet. The 14, 18 and 24 microsecond intervals correspond to a system pulse repetition frequency of 35.5 kc, 28 kc and 21 kc respectively. In the high-altitude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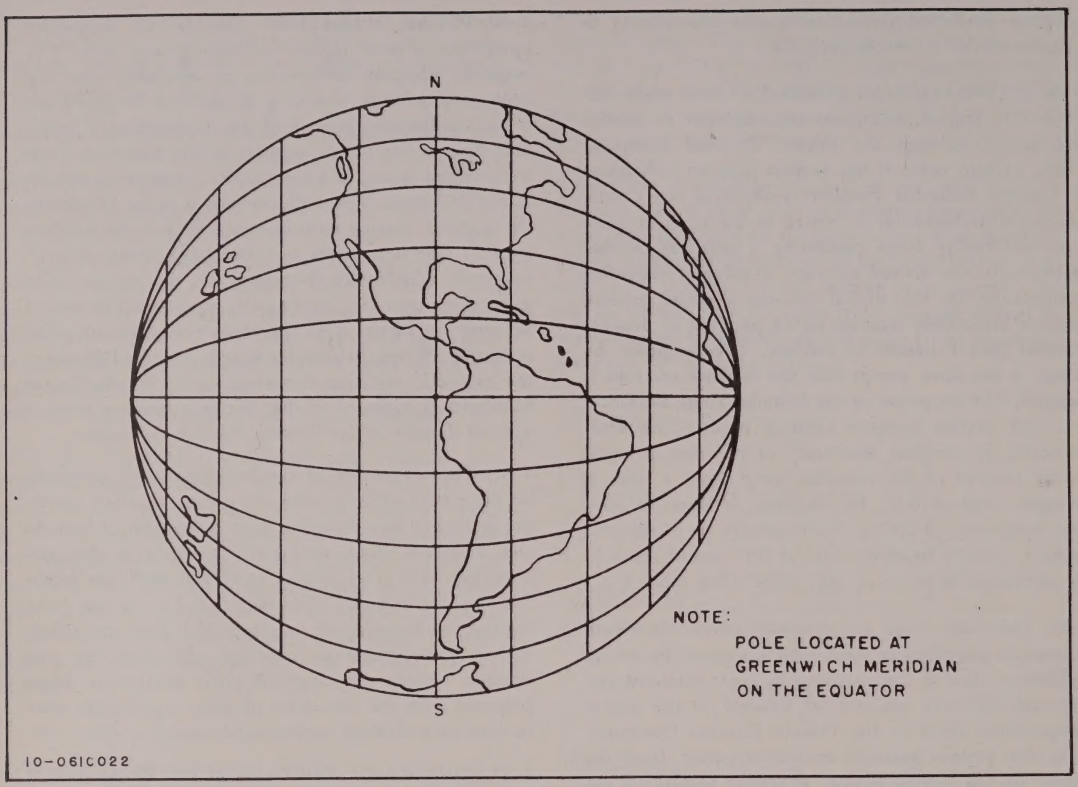

Figure 4–2. Transverse Coordinate Grid System

the frequency generator. The gate generator, in conjunction with the baroswitch, supplies the frequency generator with transmitter and receiver gates. The "on-off" timing of these gates is controlled by the gate generator. The gates alternately enable r-f signals at the output of the frequency generator which, in turn, alternately enables the transmitter and the receiver.

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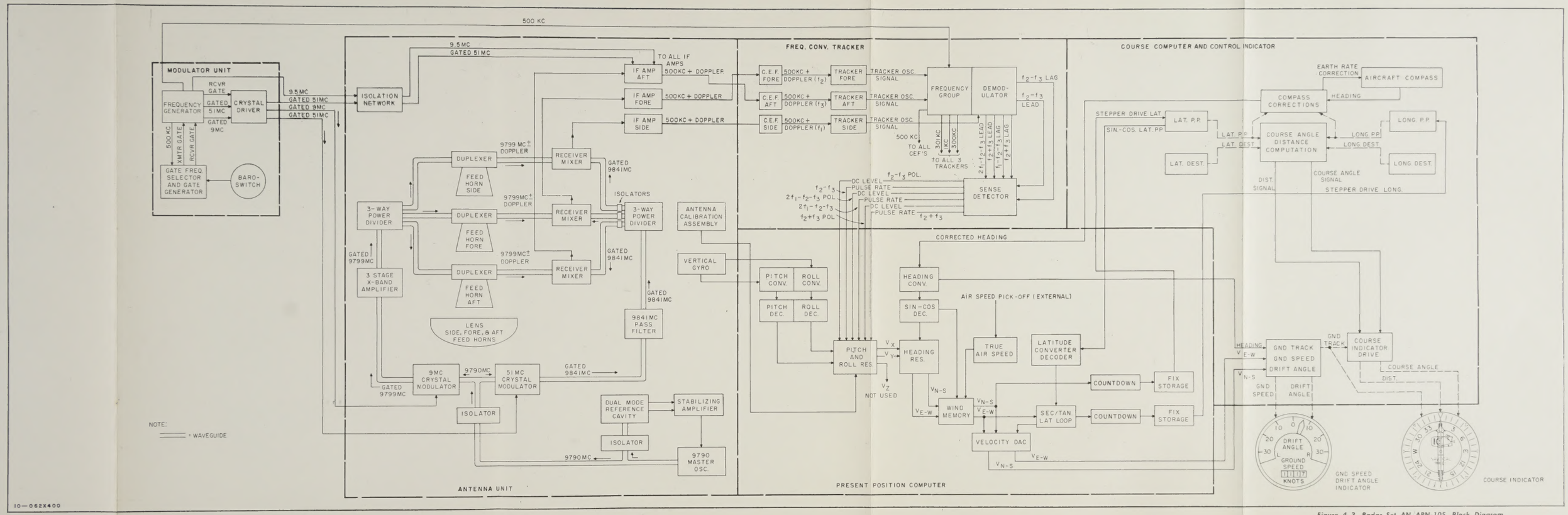

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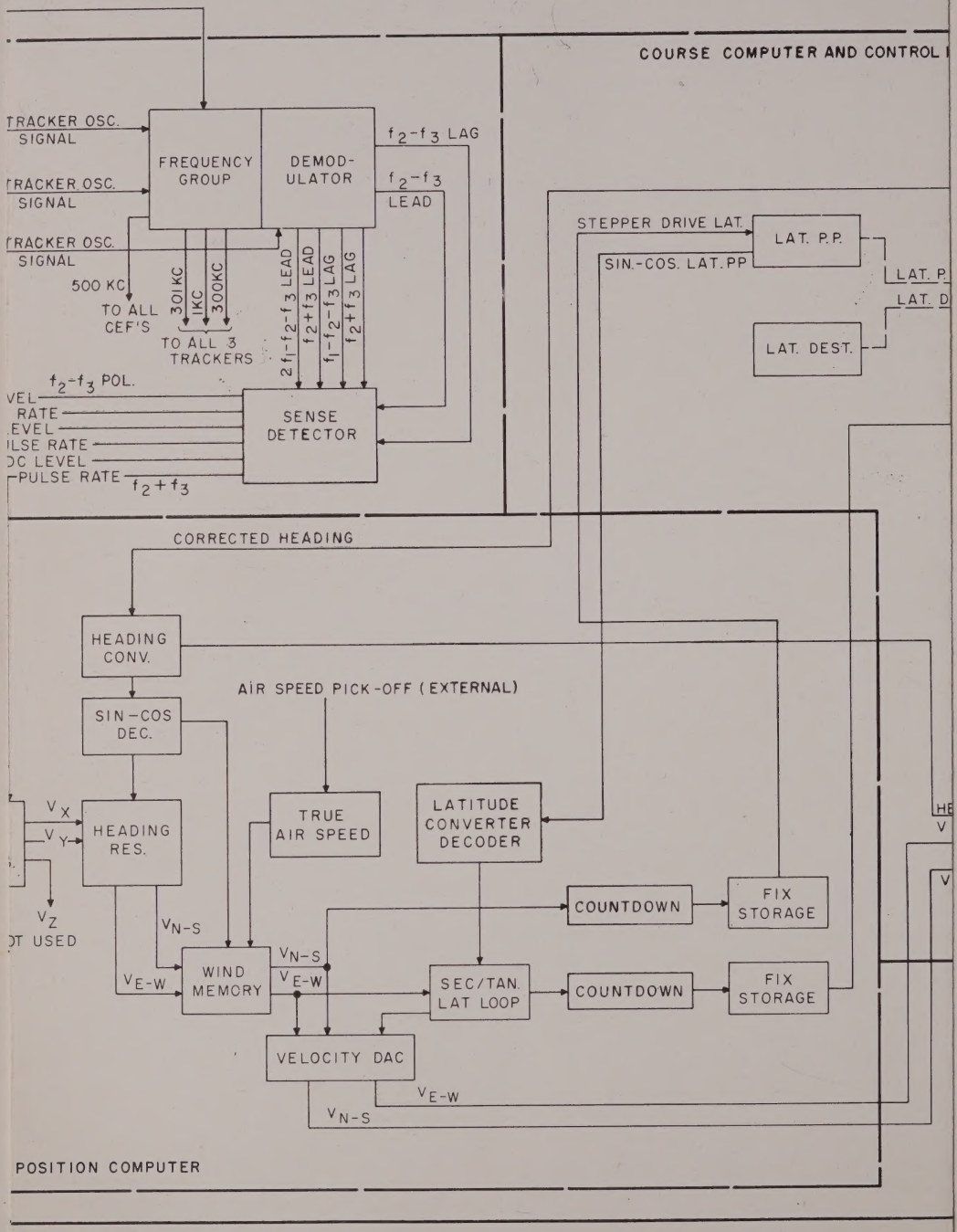
Figure 4–3. Radar Set AN/APN-105, Block Diagram


COURSE COMPUTER AND CONTROL
TRACKER OSC. SIGNAL
TRACKER OSC. SIGNAL
TRACKER OSC. SIGNAL
FREQUENCY GROUP
DEMOD-ULATOR
f_2-f_3 LAG
f_2-f_3 LEAD
500 KC
TO ALL CEF'S
301 KC
1 KC
300 KC
TO ALL 3 TRACKERS
$2f_1-f_2-f_3$ LEAD
f_2+f_3 LEAD
$f_1-f_2-f_3$ LAG
f_2+f_3 LAG
f_2-f_3 POL.
VEL
RATE
EVEL
ILSE RATE
DC LEVEL
PULSE RATE
f_2+f_3
SENSE DETECTOR
STEPPER DRIVE LAT.
SIN.-COS. LAT. PP
LAT. P.P.
LAT. P
LAT. D
LAT. DEST.
CORRECTED HEADING
HEADING CONV.
AIR SPEED PICK-OFF (EXTERNAL)
SIN-COS DEC.
V_X
V_Y
HEADING RES.
V_Z
OT USED
TRUE AIR SPEED
LATITUDE CONVERTER DECODER
HE
V
V
COUNTDOWN
FIX STORAGE
V_{N-S}
V_{E-W}
WIND MEMORY
V_{N-S}
V_{E-W}
SEC/TAN. LAT LOOP
COUNTDOWN
FIX STORAGE
VELOCITY DAC
V_{E-W}
V_{N-S}
POSITION COMPUTER

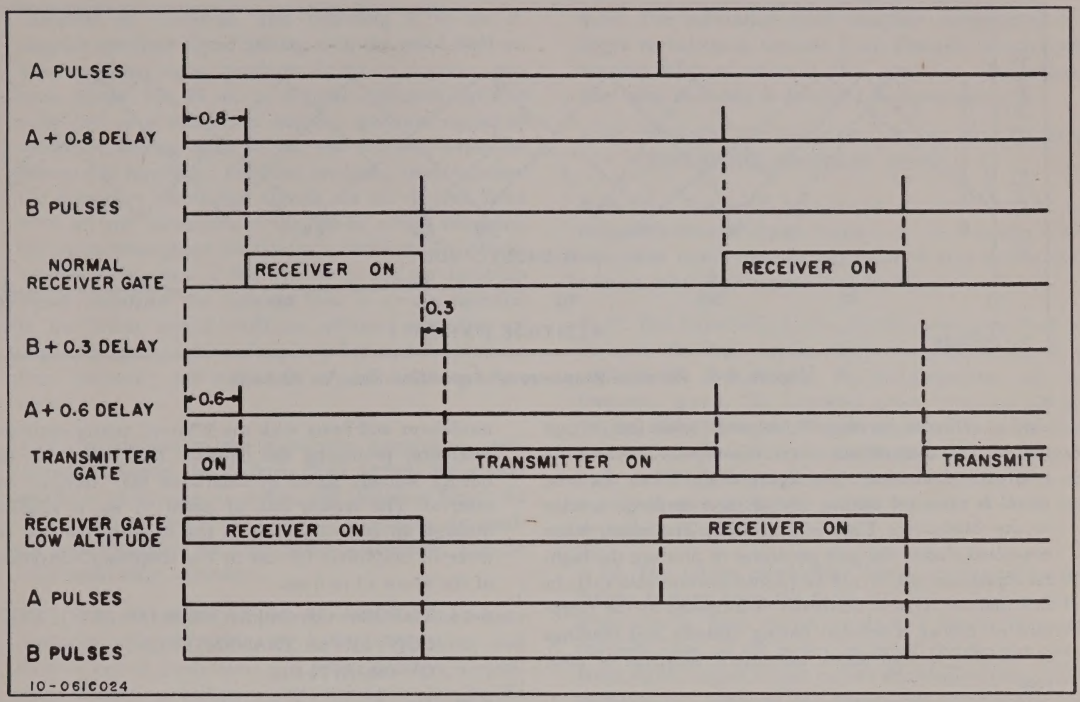


Figure 4–4. Transmitter and Receiver Intervals

step, the output of the baroswitch is used to adjust the voltage levels within the gate generator so that the 14-microsecond interval is replaced by a 20-microsecond interval. This allows the gate generator to produce sequential transmit-receive intervals of 20, 18, and 24 microseconds so that echo reception is assured at all altitudes between 35,000 and 70,000 feet. The 20, 18 and 24 microsecond intervals correspond to a system pulse repetition frequency of 25 kc, 28 kc and 21 kc respectively.

4–38. The gate generator, in conjunction with the baroswitch, determines a suitable pulse repetition frequency. The selected pulse repetition frequency is used to produce transmitter gates which turn on and off the output of the frequency generator that goes to the transmitter modulator over in the Antenna Unit. Also produced are receiver gates which turn on and off the output of the frequency generator that goes to the receiver modulator over in the Antenna Unit. These outputs of the frequency generator determine the "transmitter on" and "receiver on" intervals.

4–39. Three repetition rates corresponding to the three transmit-receive intervals are used to enable the frequency generator. Each repetition rate is above the highest doppler frequency to eliminate the possibility of the trackers locking on a repetition rate signal. Figure 4–5 shows the relative return response at each repetition rate vs altitude. If the minimum repetition rate of 21 kc were used exclusively, for example, altitude response holes would occur at multiples of 24,000 feet. Since the round-trip transit time at this altitude is approximately equal to the repetition rate period, ground-reflected signals are received during the "receiver off" interval. Therefore, to eliminate these altitude holes, two other repetition rates above the highest doppler frequency are combined with the basic 21-kc repetition rate. For example, the 28-kc repetition rate results in a hole at 18,000 feet and its second response maximum occurs at 27,000 feet. Thus, the 24,000-foot hole in the 21-kc repetition rate is eliminated by mixing it with a 28-kc repetition rate. The three repetition rates are cycled at 150 cps so that equal time is allotted to transmission at each repetition frequency.

4–40. The gate generator eliminates altitude holes by utilizing different transmission intervals in turn at altitudes between 2000 and 35,000 feet. Each of the three sequential intervals is selected at approximately 50 cps. The interval samples are chosen so as to limit the average signal level. The same set of transmission intervals is

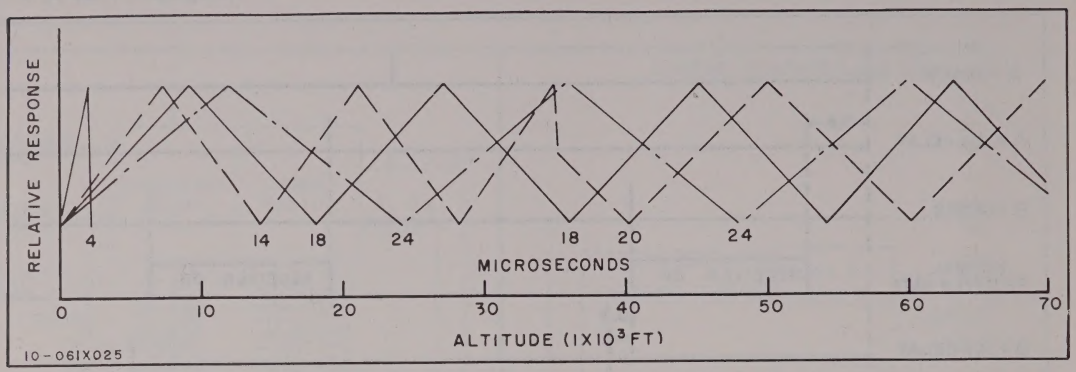


Figure 4–5. Relative Response of Repetition Rate Vs Altitude

used at altitudes between 35,000 and 70,000 feet, except that the 14-microsecond interval is replaced with a 20-microsecond interval. (See figure 4–5.) When the nose wheel is extended during takeoffs and landings, a relay in the Modulator Unit is energized. The relay, when energized, forces the gate generator to produce the highest repetition rate of 125 kc (4-microsecond interval). In this manner, system sensitivity is increased as the reception of echoes is assured during takeoffs and landings at airfields located above barometric altitudes of 2000 feet.

4–41. The frequency generator produces a continuous 500-kc signal for use as the pulse repetition frequency reference in the gate generator and for us in the carrier elimination filters in the Tracker Unit. Harmonics of this 500-kc are used to generate 9.0-mc, 9.5-mc and 51-mc. The 9.0-mc is gated by the transmitter gate from the gate generator and the 51-mc is gated by the receiver gate.

4–42. The r-f amplifier amplifies the gated 9-mc and gated 51-mc outputs of the frequency generator, and supplies these signals to the Antenna Unit.

4–43. The outputs from the Modulator Unit are 500-kc, 9.5-mc, and gated 9-mc and 51-mc signals. The 500-kc signal is supplied to the Tracker Unit to provide the modulation reference in the carrier elimination filters. The 9.5-mc signal is supplied to the Antenna Unit where it is applied through an isolation filter to the three i-f amplifiers for use in the frequency conversion of 9 mc ± doppler to 500 kc ± doppler. The gated 9-mc signal is supplied to the Antenna Unit and then through a crystal current limiter to the transmitter crystal modulator. The 9 mc beats with the transmitter 9790-mc master oscillator reference, producing the 9799-mc transmitter frequency suitably gated to determine the "transmitter on" interval. The gated 51 mc is supplied to the Antenna Unit on two lines. One line of gated 51 mc is supplied to the receiver crystal modulator and beats with the 9790-mc master oscillator reference, producing the 9841-mc local oscillator frequency suitably gated to determine the "receiver on" interval. The second line of gated 51 mc is supplied through an isolation filter in the Antenna Unit to the three i-f amplifiers for use in the frequency conversion of the 42-mc i-f to 9 mc.

4–44. THEORY OF OPERATION OF FREQUENCY CONVERTER-TRANSMITTER CV-448/APN-105.

4–45. The Antenna Unit radiates three narrow beams of 9799-mc energy toward the ground and receives the resulting three separate 9799-mc ± doppler spectrum reflections from the ground. The three 9799 mc ± doppler spectrum signals are converted by circuits in the Antenna Unit into 500 kc ± doppler spectrum signals. The three 500 kc ± doppler spectrum signals are supplied to the Tracker Unit for further processing. (See figure 4–3.)

4–46. The transmitter and receiver are enabled alternately, each for approximately the same length of time. Enabling signals for the transmitter and receiver are generated in the Modulator Unit and supplied to the Antenna Unit. The Modulator Unit supplies a gated 9-mc signal for transmitter enabling, and a gated 51-mc signal for receiver enabling.

4–47. All frequencies employed in the Antenna Unit are derived from two basic frequencies, 500 kc and 9790 mc. The 9-mc, 9.5-mc, and 51-mc signals employed in the Antenna Unit are derived from harmonics of the 500-kc crystal reference located in the frequency generator subassembly of the Modulator Unit. The 9790-mc signal is generated by the Antenna Unit master oscillator. The 9790 mc is mixed with gated 9 mc to produce the gated transmitter frequency of 9799 mc present during the "transmitter on" interval. The 9790 mc is also mixed with gated 51 mc to produce the local oscillator gated 9841 mc which is used to determine the

"receiver on" interval. The returning 9799 mc ± doppler spectrum signal beating with the gated 9841-mc local oscillator signal produces 42 mc ± doppler spectrum signal. The 42 mc ± doppler spectrum signal is converted to a 500 kc ± doppler spectrum signal by successive mixing with 51 mc and 9.5 mc. Since the transmitter frequency, the local oscillator frequency and the frequency conversion signals are all derived from 9790 mc and harmonics of the 500-kc crystal reference, coherence throughout the system is obtained. The 500-kc reference frequency of the 500 kc ± doppler spectrum signal output of the Antenna Unit is always identical to the 500-kc crystal oscillator reference regardless of slight changes in relative frequency between the 9790-mc basic frequency and the 500-kc crystal oscillator reference.

4–48. In addition to the microwave components, subassemblies within the Antenna Unit include the master oscillator stabilizing amplifier, the isolation filter, the crystal current limiter the three i-f amplifiers, the vertical gyro assembly, the filter network assembly, and the calibration relay assembly.

4–49. The microwave components consist of the master oscillator and its monitoring cavity, transmitter and receiver crystal modulators and power dividers, a three-stage X-band amplifier, a 9841-mc filter, five ferrite isolators, three local oscillator mixers, three feedhorns with their associated duplexers, and associated waveguide.

4–50. The stabilizing amplifier is part of the loop used to stabilize the master oscillator frequency. The isolation filter couples the 9.5-mc and gated 51-mc frequency conversion signals from the Modulator Unit to the three i-f amplifiers. The three r-f amplifiers amplify and convert the 42 mc ± doppler spectrum signal outputs from each local oscillator mixer to 500 kc ± doppler spectrum signals which are then supplied to the Tracker Unit.

4–51. The vertical gyro assembly is located within the Antenna Unit and provides indications of aircraft roll and pitch. Roll and pitch are synchro-transmitted to the Present Position Computer for use in compensating aircraft motion, referred to horizontal and vertical axes for aircraft pitch and roll.

4–52. The crystal current limiter is necessary to couple maximum 9-mc power to the crystals of the transmitter modulator.

4–53. The filter network assembly filters the 51-mc power to the receiver modulator. The filter especially rejects any 42 mc that may be produced in the Modulator Unit from 51-mc and 9-mc interaction.

4–54. The calibration relay assembly compensates for slight variations in antenna beam direction and for the skewing effect of water in SEA operation. The calibration relay assembly is discussed in paragraph 4–87.

4–55. THEORY OF OPERATION OF FREQUENCY CONVERTER-TRACKER 58003.

4–56. The Tracker Unit converts the three 500 kc ± doppler spectrum signal outputs of the Antenna Unit into pulse trains representing forward, side and vertical motion referred to aircraft coordinates.

4–57. The major circuit networks comprising the Tracker Unit are the three carrier elimination filters; the three trackers, the demodulator, the sense detector, and the frequency group. The frequency group generates 300 kc, 301 kc, and 1 kc required by the trackers. It also doubles the 500-kc reference from the Modulator Unit to produce a 1000-kc reference and adds the fore and aft tracker outputs to supply a 1000 kc + f_2 + f_3 to the demodulator. (See figure 4–3.)

4–58. The carrier elimination filters remove unwanted 500-kc leakage from the three 500 kc ± doppler spectrum signals. Each tracker produces a single frequency corresponding to the power center of the doppler spectrum signal output of the carrier elimination filters. The demodulator combines the frequencies representing the doppler returns of the three beams in accordance with the formulas for forward, side and vertical motion. The sense detector converts the frequencies representing forward, side and vertical velocity into pulse trains and, in addition, produces the polarity of the side and vertical velocity signals. Right and down velocities are signified by positive polarities.

4–59. The three doppler spectra from the three i-f amplifiers in the Antenna Unit contain unwanted leakage at the frequency-converted carrier frequency (9799 mc beat down to 500 kc). The main source of leakage in this system is caused by the overlap of "transmitter on" and "receiver on" intervals at the lowest altitude step. The transmitter energy leaks across the duplexer directly into the enabled receiver. Some leakage, at all altitudes, comes from transmitter energy leakage across the duplexer directly into the disabled receiver (disabling does not completely cut off the receiver). Also, when the transmitter is off, noise generated at 9799 mc by the X-band amplifiers leaks into the enabled receiver. The carrier elimination filters remove the 500-kc component from the 500 kc ± doppler spectrum signal inputs to the Tracker Unit. The method employed reduces the 500-kc component to a minimum with no effect upon the doppler spectrum signal, which is above or below the 500-kc reference by the amount of the doppler shift.

4–60. D-C filtering removes the 500-kc component of the signal without affecting the doppler spectrum signal itself. The 500 kc ± doppler spectrum signal is beat against the 500-kc reference from the frequency generator located in the Modulator Unit. Because harmonics of the same 500 kc have been used to effect frequency conversion of the 9799 mc ± doppler spectrum signal to the 500 kc ± doppler spectrum signal, the 500-kc component of the 500 kc ± doppler spectrum signal is always exactly the same frequency as the 500-kc reference from the Modulator Unit. The difference between these two frequencies is the actual doppler shift in cycles per second, referred to 0 cycles. Thus, the unwanted leakage occurs at 0 cycles of this audio doppler frequency. The audio doppler spectrum signal is carried in quadrature channels to preserve the sense of the original doppler shift (whether above or below 500 kc). A d-c filter in each channel rejects the audio component below 15 cycles and passes the remainder. The audio doppler spectrum signal in each channel is then modulated about the 500-kc reference from the Modulator Unit. The output of each channel is a double sideband suppressed carrier signal. The channel outputs are added algebraically, resulting in a single sideband signal that contains a spectrum of frequencies above or below 500 kc by the amount of the doppler shift. The output of the carrier elimination filter is then identical to the input minus whatever 500-kc leakage that was present in the input signal.

4–61. Doppler information lost by the d-c filtering is negligible. The d-c filter rejects only velocities causing less than 15 cycles of doppler shift, which are speeds slower than 12 inches per second (1.5 knots) along the beam axis. In the case of fixed-wing aircraft, the doppler shifts of the fore and aft beams will always be considerably higher than 15 cycles. Therefore, the forward and vertical velocities will not be affected even if the vertical contribution happens to be less than 12 inches per second.

4–62. Included in the fore and aft carrier elimination filter assemblies is a notch filter. These filters are tuned (notched) to pass frequencies corresponding to normal aircraft cruising speeds and to reject low frequencies corresponding to low aircraft velocities. This prevents the system from locking onto a transmitted side lobe which may give a relatively strong signal return when over water. The strong side lobe is beamed directly down toward the water so it will always contain a low-frequency doppler shift. When the nose wheel is down, a switch is closed which energizes the relays in the fore and aft carrier elimination filter assemblies. When energized, these relays alter the tuning of both notch filters such that low frequencies are no longer rejected. The aircraft nose wheel is down just before landing and during takeoff when the aircraft's speed is low, and consequently the doppler shift would be low. By this means, the notch filters never reject frequencies caused by true aircraft motion. As the aircraft gains speed and the nose wheel is retracted, the relays will be de-energized and the fore and aft notch filters will then be returned to pass only the higher frequencies that may now be expected.

4–63. The doppler return consists of a spectrum of frequencies because the antenna beamwidth is finite. The frequency of doppler return for a moving transmitter varies with the angle formed by the transmitted beam and the direction of motion. The beam depression angle is a nominal 70° from the fuselage. Since the beam is about 6.5° wide, it is readily apparent that the near and far edges of the beam with respect to the aircraft represent different beam depression angles. Reflections are returned to the receiver throughout a 6.5° spread of angles. The single transmitted frequency thus gives rise to a spectrum of doppler returns, each frequency in the doppler return corresponding to some particular point of the reflecting surface. Since the beam is widest and strongest at its center, maximum power will be returned at a frequency corresponding to the center of the beam, the same doppler frequency being generated by all points in the beam that are of the same beam depression angle. For a given horizontal motion, the doppler shift will be smallest from that portion of the beam representing the greatest beam depression angle (near edge). Doppler shift also varies proportionally with aircraft velocity. The greater the velocity, the wider the returned spectrum (zero velocity, of course, returns a single frequency, the transmitted frequency). Doubling the velocity doubles the doppler shifts produced from both the near and the far edges of the finite beam. Doubling two bounding frequencies doubles the separation between these two frequencies; thus, the spectrum width increases as the doppler shift increases.

4–64. When over water, doppler shift will vary with the sea-state condition because the effects of back-scatter on water surfaces, particularly smooth water, tend to shift the power center of the beam. Therefore, more of the doppler return signal appears from the portion of the beam representing the greatest beam depression angle (the near edge). The power of the returned doppler spectrum thus corresponds to a greater beam depression angle than is actually the case. However, the apparent increase in beam depression angle is corrected by increasing the number of pulses in the horizontal pulse trains by 3 per cent. This is accomplished by turning the Operate Switch to the SEA position.

4–65. The three doppler spectrum signals from the carrier elimination filters are each sent to three respec-

tive trackers (fore, aft and side) whose functions are to produce a single frequency corresponding to the power center of its input doppler spectrum.

4–66. In each of the three trackers, this single frequency is produced by a frequency-controlled oscillator. The oscillator frequency is regulated by a control loop which forces the oscillator to follow the center of power of the doppler spectrum signal from the carrier elimination filter. This tracker output is beat with the doppler spectrum signal input to the tracker, producing a band of audio error frequencies. The audio is carried in quadrature channels to preserve the relationship (above or below) of input to output frequency. A constant 90° phase shift is introduced between the audio channels independent of the frequency of audio error signals. The quadrature channels modulate two carriers, and the difference (1-kc) is phase-compared with the 1-kc reference supplied by the frequency group. The result of the phase comparison is used to drive the tracker oscillator in a direction to minimize the audio error frequencies and thus to produce a frequency corresponding to the input frequency — or, to be more accurate, to the power center of the input doppler spectrum.

4–67. The system bandwidth, as determined by the characteristics of the carrier elimination filter, is 24 kc. Before the tracker locks on an input spectrum, it must detect the doppler spectrum signal from the wide band noise contained within the bandpass of the carrier elimination filter.

4–68. The three tracker oscillators are tuned to vary over frequencies appropriate to the requirements of each particular tracker. The fore tracker oscillator range is tuned to cover approximately 483 to 500 kc. In fixed wing aircraft, the fore doppler spectrum signal is normally below 500 kc because of initial positive doppler shift at the Antenna Unit and the three frequency conversions of the doppler carrier to 500 kc.

4–69. Similarly, the aft tracker oscillator range is tuned to cover approximately 500 to 517 kc. The initial doppler shift is below the carrier frequency but is reversed to a shift above the 500-kc reference by the three frequency conversions in the Antenna Unit. The side tracker oscillator range is centered at 500 kc, since doppler return is equally likely to be above or below the transmitter frequency.

4–70. Once a tracker is driven into the vicinity of the doppler spectrum signal, the spectrum signal is sensed and the tracker narrow-bands to ±400 cycles. In narrow-banding, only an 800-cycle band within the doppler spectrum signal, plus noise in that 800-cycle band, affects the tracker oscillator frequency. The tracker oscillator drives to the center of power of the 800-cycle band (the center of the doppler spectrum signal). Narrow-banding adds approximately 6 db of effective noise suppression to the tracking system.

4–71. The three tracker outputs are single frequencies above or below 500 kc by the number of cycles of doppler shift. The tracker outputs are supplied to the demodulator where they are converted to terms representing velocity along three mutually perpendicular aircraft coordinates, referenced to the aircraft frame (forward, side, and vertical). The tracker outputs are combined according to the formulas: forward velocity $= f_2 - f_3$, side velocity $= 2f_1 - f_2 - f_3$, vertical velocity $= f_2 + f_3$. These formulas separate the forward, side and vertical contributions to the doppler shifts of the three beams. The results of the demodulator operations eliminate the 500-kc reference expressing velocity directly in cycles per second. The side and vertical demodulator outputs are carried to the sense detector in quadrature channels, thus preserving the sense of the side and vertical velocities. As the aircraft's fore-aft velocity is always forward, no polarity is required for the fore-aft velocity which therefore has only a single output from the demodulator.

4–72. The sense detector converts the sine waves of each term into pulses, one pulse per cycle, and also determines the polarity of the side and vertical velocities. The three pulse trains, V_{xa} (forward), V_{ya} (side) and V_{za} (vertical), together with the two polarity indications, are supplied to the Present Position Computer for further processing.

4–73. THEORY OF OPERATION OF COMPUTER, NAVIGATIONAL, POSITION 60301.

4–74. GENERAL. The Present Position Computer converts information representing velocity along three mutually perpendicular coordinates related to the aircraft into pulses representing aircraft velocity in minutes of latitude and longitude on the earth's surface. It also generates a pulse rate proportional to the aircraft's vertical velocity and precision a-c voltages proportional to the aircraft's east-west and north-south velocities. (See figure 4–3.)

4–75. The input to the Present Position Computer consists of three pulse trains from the Tracker Unit together with polarity indications for the side and vertical trains. These pulse trains represent forward, side and vertical velocity with respect to the aircraft. These pulse trains are counted down and calibrated. The calibration corrects for the beam depression angle, different calibrations being used over land (NORM) and water (SEA). (See paragraph 4–87.)

4–76. The roll-pitch resolution converts the calibrated pulse trains into information representing velocity along three mutually perpendicular coordinates referenced to a horizontal plane.

4–77. Horizontal forward and horizontal side velocities are converted by the heading resoultion into aircraft velocities in north-south and east-west directions.

4–78. Velocity north-south and velocity east-west pass through the wind memory circuits. Normally, the wind memory circuits calculate the wind speed from a comparison of air speed and true ground velocity. The calculated wind speed is stored in the wind memory circuit. When the SEA mode of operation is selected, the calculated wind speed is frozen at the time the system is switched to SEA. This is to prevent a false wind speed from being developed, should the trackers lock onto a side lobe. (See paragraph 4–62.) At times of insufficient doppler return, ground speed is calculated from stored wind speed and air speed. The north-south velocity from the wind memory is supplied to the final count-down. The east-west velocity from the wind memory is supplied to the secant latitude loop. Both north-south and east-west velocity from the wind memory are also supplied to the digital-to-analog converter.

4–79. The secant latitude loop multiplies the east west velocity from the wind memory by the secant of present position latitude. The result is east-west motion in minutes of longitude at all values of present position latitude. The output of the secant latitude loop is supplied to the final count-down.

4–80. The final count-down converts the north-south velocity from the wind memory into pulses representing aircraft movement in minutes of latitude. The final count-down converts the output of the secant latitude loop into pulses representing aircraft movement in minutes of longitude. The outputs of the final count-down are supplied to fix storage.

4–81. The counted-down latitude and longitude pulses are sent through fix storage to the stepper drive. The stepper drive actuates the stepper motors located in the Course Computer. Fix storage stores counted-down pulses during times that the present position coordinates are being reset, then channels the pulses back into the system.

4–82. CALIBRATION MULTIPLIERS. There are three pulse train inputs to the roll-pitch resolution section of the Present Position Computer. These pulse trains are supplied from the Tracker Unit. They represent forward ($f_2 - f_3$), side ($2f_1 - f_2 - f_3$), and vertical ($f_2 + f_3$) velocities with respect to the aircraft. Each pulse train is supplied to its separate calibration multiplier. These calibration multipliers serve three purposes, which will be discussed separately below. The first is to reduce the computing pulse rate within the Present Position Computer to a more convenient value. The second is to compensate for the difference in weighting between pulses on the vertical velocity line and those on the two horizontal velocity lines. Compensation may be varied according to slight deviations of the antenna beam depression angles from their nominal value of approximately 70°. The third is to provide for alternate compensation for water bias. Water bias is the apparent change in antenna beam depression angle which occurs when the reflecting surface is water.

4–83. A single pulse at the input to the Present Position Computer represents a distance moved of approximately 0.9 inch in the horizontal direction and approximately 0.3 inch in the vertical direction. A single pulse at the output of the Present Position Computer represents 0.4 nautical mile (at the equator). Thus a considerable pulse weight count-down is accomplished within the Present Position Computer. The calibration count-down is an approximate factor of eight for the forward and side pulse trains to give convenient pulse rates for the various mathematical operations.

4–84. The calibration multiplier for vertical velocity ($f_2 + f_3$) counts down by a larger factor than the other two for the following reason. The doppler shift in the return of any receiver channel is directly proportional to aircraft velocity in the direction of the antenna beam for that channel. A particular aircraft velocity in a direction other than along the beam will produce less doppler shift in the channel for that beam. The relationship in the forward and side direction follows a cosine curve; that is, doppler shift is proportional to aircraft velocity times the cosine of the angle between the velocity vector and the antenna beam. All antenna beams are depressed approximately 70.25° from the plane of the fuselage (at 0% calibration) so forward or side velocity causes a doppler shift in the return of a particular beam which is less by cos 70.25° than that which would result from the same velocity along that beam.

4–85. However, for sensing vertical velocity, the beams are oriented only 19.75° away from the optimum direction (at 0% calibration) so that a given vertical velocity produces a doppler shift reduced by a factor of only cos 19.75° (= sin. 70.25°). Thus, vertical velocity enjoys a signal sensitivity advantage of sin. 70.25°/cos 70.25° (= tan. 70.25° = 2.7852), compared to horizontal velocity. (See paragraph 4–26.)

4–86. The Present Position Computer must operate upon pulse trains having equal velocity (or distance) signi-

ficance. Therefore, for a 70.25° beam depression angle, the input calibration corrects for the difference in pulse weighting of the $f_2 + f_3$ (vertical velocity) input pulse rate by counting V_z down by an additional factor of 2.7852. This is equivalent to dividing V_z by the tangent of 70°. Thus, at the output of the three calibration multipliers, the pulses in each of the three pulse trains signify the same distance moved (7.1 inches per pulse).

4–87. The forward and side pulse trains may be multiplied by any factor from 0 to 0.25, according to the gating arrangement set up in the calibration relay assembly located in the Antenna Unit. The vertical pulse train is multiplied by a fixed factor of 0.045; any inaccuracies in the vertical multiplication have a negligible effect on system accuracy; therefore, no vertical calibration is provided. Thus, the range of effective multiplication of the forward and side pulse trains with respect to the vertical pulse train may be varied from 0.25/0.045 = 5.555 (tan. 79.8°) to 0./0.045 = 0 (tan. 0°). The beam depression angle will be close to 70°, probably about 70.25°. Therefore, the forward and side pulse train multiplication called for will be in the vicinity of 0.1253, corresponding to 70.25° (0.1253/0.045 = 2.7852 = tan. 70.25°). The alternate multiplication afforded the forward and side pulse trains by gating from the calibration relay assembly when the Operate Switch is in the SEA position, is 3 per cent greater, compensating for the apparent increase in beam depression angle (less than 1°) when operating under SEA conditions. The actual beam depression angle and, therefore, the particular calibration required for a particular Antenna Unit, is determined by flight-testing each Antenna Unit. The required calibration is wired into the calibration relay assembly in the Antenna Unit, and the calibration code is stamped on the outside of the Antenna Unit.

4–88. When the Operate Switch is in the NORM position, the calibration is for a beam depression angle of about 70.25°.

4–89. Flights over water surfaces require a different calibration factor than flights over land. The radar beam has a finite width. The far edge of the beam has a smaller depression angle than the near edge of the beam. Doppler returns from all portions of the beam reach the receiver. Since different beam depression angles cause different doppler shifts for the same aircraft velocity, a spectrum of doppler shifts return to the receiver. Over land surfaces, the amplitudes of the doppler return do not vary appreciably with the beam depression angle. Therefore, the distribution of power vs frequency in the doppler return corresponds to the distribution of power vs depression angle in the transmitted beam. Since maximum power is concentrated at the center of the radar beam, maximum power is also found at the frequency in the returned doppler spectrum signal corresponding to the center angle of the beam. Each tracker follows the center of power of the spectrum signal returned to it and thus produces the correct frequency for the antenna beam depression angle.

4–90. Over water, the transmitted beam is reflected as from a mirror-like surface (more markedly so as the water gets smoother). The amplitude of the doppler returns varies substantially over small changes in the beam depression angle. More of the doppler return thus appears from that portion of the beam representing the greatest beam depression angle (the near edge). The power center of the returned doppler spectrum signal thus corresponds to a greater beam depression angle than is actually the case.

4–91. When the aircraft is over water surfaces, the calibration must be corrected for the apparent increase in beam depression angle. This correction is accomplished by turning the Operate Switch to the SEA position. This increases the number of pulses in the horizontal pulse trains by 3 per cent, thereby introducing a constant factor that will compensate for the over-water bias. Also, the wind memory registers are latched to prevent false wind storage information if the system should lock onto a side lobe return over smooth water. (See paragraph 4–62.)

4–92. When over smooth water (less than Beaufort 1), the doppler spectrum may at times become too weak to operate any one of the three trackers, or the trackers may lock onto a transmitted side lobe which may give a relatively strong signal return. (See paragraph 4–62.)

4–93. If the system is in NORM operation and any one of the trackers unlocks, the system will switch automatically to memory operations as indicated by the MEMORY lamp on the Control Indicator illuminating. In memory operation, the last known wind velocity before the loss of doppler return is retained in the wind memory circuit. This wind velocity is added to the air speed input from the Air Data Computer (not part of Radar Set AN/APN-105) and forms an approximate ground speed which replaces the velocity information obtained from the radar beams. This allows the computation of present position to continue uninterrupted. When doppler return is again strong enough to operate all three trackers, the MEMORY lamp will extinguish and the system will return to normal operation.

4–94. If the system is in SEA operation when one of the trackers unlocks, the results are the same as before except that the wind velocity stored in the wind memory circuits will be the wind computed just prior to going

into SEA operation. (See paragraph 4–91.) The wind velocity can be updated periodically by turning the Operate Switch to the NORM position for at least 10 seconds and then back again to the SEA position.

4–95. If the trackers lock onto a transmitted side lobe during SEA operation, the ground-speed and drift-angle indications will become erratic. In this case, the Operate Switch must be switched to the SIL position. When the Operate Switch is in the SIL position, the system is forced into wind memory operation. During this time, periodically check the ground-speed and drift-angle indications to determine when the trackers unlock from the transmitted side lobe. This is accomplished by turning the Operate Switch back to the SEA position and noting the ground-speed and drift-angle indications. If the trackers have again locked onto the power center of the returned doppler spectrum signal, the ground-speed and drift-angle indications will be constant and the system can then be left in SEA operation.

4–96. ROLL AND PITCH RESOLUTION. The outputs of the three calibration multipliers are designated calibrated V_{xa}, V_{ya} and V_{za}. These pulse trains represent forward, side and vertical velocity with respect to the aircraft. The pulses in each train signify the same distance travelled (7.1 inches).

4–97. The remaining circuits in the roll-pitch resolution convert calibrated V_{xa}, V_{ya} and V_{za} into pulse trains representing true horizontal and vertical velocity with respect to the ground. That is compensation is made for roll and pitch, so that V_x, V_y and V_z may be obtained, signifying velocity with respect to earth coordinates.

4–98. The roll-pitch resolution is designed to compensate accurately for roll and pitch angles over a range of ±20°. Compensation continues to ±27-1/2°, but with a slight degradation of navigational accuracy. The system is automatically forced into memory operation when the roll or pitch angle exceeds ±27-1/2° and automatically returns to normal operation when the roll or pitch angles become less than ±27-1/2°.

4–99. Should an extreme attitude be maintained (greater than 27-1/2° in pitch or roll), a limit switch in either the pitch or roll converter will operate and place the system in the wind memory mode. The system will continue to compute present position by the function of wind memory. (See paragraph 4–126.) The navigator will again compute present position from ground referenced data when the pitch and roll angles are once again within the accuracy requirements of the roll-pitch resolution.

4–100. The theoretical solution for V_x (horizontal forward velocity) is:

$$V_x = V_{xa} \cos P + V_{ya} \sin. P \sin. R + V_{za} \sin. P \cos R,$$

where P = pitch angle; R = roll angle. The actual formula solved by the roll-pitch resolution is a practical approximation of the theoretical soultion:

$$V_x = V_{xa} - V_{xa} P^2/2 + V_{ya} RP + V_{za} P$$

This approximation of the V_x soultion is obtained as follows: cos P is not generated; therefore, an approximation of the term V_{xa} cos P is used instead. Cos P is approximately equal to $1 - P^2/2$. V_{xa} $(1 - P^2/2) = V_{xa} - V_{xa} P^2/2$. Therefore, $V_{xa} - V_{xa} P^2/2$ is substituted for V_{xa} cos P.

4–101. Roll and pitch angles under ordinary flying conditions are assumed to be less than ±20°. For angles less than 20° the angular measurement in radians of an angle is equivalent to the sine of that angle within the accuracy requirements of the roll-pitch resolution. Therefore, the term V_{ya} RP may be substituted for the term V_{ya} sin. P sin. R. For angles between 20° and 27-1/2°, the error is the difference between the radian value of the angle and the sine of the angle.

4–102. The V_{za} sin. P cos R term is less significant in the solution for horizontal forward velocity. (A 20° roll angle here can make only a 6 per cent change in a term whose normal contribution to forward and side velocity is less than 2 per cent). Therefore, the cos R factor is assumed to be unity, giving the pracitcal approximation $V_{za}P$.

4–103. The theoretical solution for V_y (horizontal side velocity) is:

$$V_y = V_{ya} \cos R - V_{za} \sin. R$$

The actual formula solved by the roll-pitch resolution is a practical approximation of the theoretical solution:

$$V_y = V_{ya} - V_{ya} R^2/2 - V_{za} R$$

The practical approximation of the V_y solution is made in the same manner as that for V_x. Since cos R is not generated, the term $1 - R^2/2$ is used instead. This V_{ya} cos R becomes $V_{ya} - V_{ya} R^2/2$. For V_{za} sin. R, R is assumed to be the same as sin. R, giving the term $V_{za} R$.

4–104. The theoretical solution for V_z (vertical velocity) is:

$$V_z = - V_{xa} \sin.P + V_{ya} \cos P \sin. R + V_{za} \cos P \cos R.$$

The formula solved in the roll-pitch resolution is:

$$V_z = V_{za} + V_{ya} R - V_{xa} P$$

4–105. The approximation is as follows: V_{xa} sin. P becomes V_{xa} P. V_{ya} cos P sin. R becomes V_{ya} R (cos P assumed to be unity). V_{za} cos P cos R becomes V_{za} (the cosine factors assumed to be unity).

4–106. Each of the multi-factor terms in the above equations is obtained by multiplying one of the calibrated pulse trains (V_{xa}, V_{ya}, V_{za}) by the required roll or pitch factor in a binary multiplier. The roll and pitch factors never exceed unity, so that the multiplication can be a process of eliminating the appropriate percent-

age of the pulses that appear at the input. The roll and pitch factors are obtained from the roll and pitch decoders in the form of binary codes which are used to gate the binary multipliers.

4–107. The roll converter and decoder are located in the Present Position Computer. The roll converter is servo-driven, the servo motor being part of the converter assembly. The input to the roll converter servo system is obtained from a synchro transmitter which is positioned mechanically by the roll inclination of the vertical gyro in the Antenna Unit.

4–108. Similarily, the pitch converter and decoder are located in the Present Position Computer. The pitch converter is servo-driven by a signal from a synchro transmitter linked to the pitch inclination of the vertical gyro. The roll and pitch converters are identical.

4–109. The roll and pitch angles introduced into the roll and pitch converters by their servo systems are converted into a binary code representing the original roll and pitch angles in radians. The converters are capable of a binary encoding of the roll and pitch angles up to 0.5 radian (27-1/2°). Owing to the increasing disparity between the binary encoding of the radian angle and the binary encoding of the sine of the angle theoretically required by the roll-pitch multipliers, accuracy decreases as the roll and pitch angles increase. At an angle of 0.368 radian (21.1°), for example, the binary code is 0101111 (0.368). However, the sine of 21.1° is 0.360, requiring a binary code of 0101110 if the sine of the angle were to be provided.

4–110. The roll and pitch converters operate in conjunction with the roll and pitch decoders to generate the binary code in appropriate potentials for gating the binary multipliers in the roll-pitch resolution. In addition, each decoder generates a number of gating potentials that signify the occurrence of double combinations of certain digits in the binary code. These gating potentials are used to gate binary multipliers producing nonlinear ($R^2/2$ and $P^2/2$) functions in the roll-pitch resolution.

4–111. The V_{xa} pulse train is applied to the V_{xa} multiplier. Two sets of output windings are associated with this multiplier. One set is gated by the binary code from the pitch decoder representing the pitch angle in radians; the output of this set is therefore V_{xa} P. The other set is gated by various single digits and pairs of digits from the decoder in such a way as to generate $V_{xa}P^2/2$.

4–112. Similarly, the V_{ya} multiplier provides outputs $V_{ya}R^2/2$ and $V_{ya}R$. The V_{za} multiplier provides outputs $V_{za}P$ and $V_{za}R$. The $V_{ya}R$ output of the V_{ya} multiplier is multipled by P in a separate multiplier, producing the term $V_{ya}RP$.

4–113. The pulses representing each of the terms in the formulas for V_x, V_y, V_z are timed in the roll-pitch resolution so that they may be added appropriately without conflict. The V_x, V_y, and V_z outputs of the roll-pitch resolution each appear on two lines: one line contains the positive contributions to that output (e.g. V_x+) and the other contains the negative contributions (eg V_x-). The magnitude of the term V_x is the difference between the number of pulses on the V_x+ and the V_x- line. The polarity of the term is determined by the line carrying the most pulses. Polarity gates channel terms (eg $V_{xa}P$) to one line or the other depending upon the polarities of the factors of each term and, hence, of the term itself. The factor polarities are obtained from the polarity signal amplifier. The polarity signal amplifiers derive roll and pitch polarities from tracks on the disks in the roll and pitch converters; the polarities of V_{ya} and V_{za} are derived by the polarity signal amplifiers from inputs from the sense detectors located in the Tracker Unit. The polarity of V_{xa} is fixed as positive (forward).

4–114. V_z (vertical velocity) is represented at the output of the roll-pitch resolution by lines V_z+ and V_z-. These lines are neither differented nor used but may be employed to operate a rate-of-climb indicator if it is so desired.

4–115. DIFFERENTIAL SYNCHRONIZER. Terms V_x+ and V_x- are differenced by the V_x differential synchronizer, producing the term V_x along with its polarity. Similarly, V_y+ and V_y- are differenced by the V_y differential synchronizer, producing the term V_y and its polarity. These pulse trains and polarity voltages are then applied to the heading resolution.

4–116. HEADING RESOLUTION. The function of the heading resolution is to convert V_x and V_y (horizontal forward and side velocities) into terms representing aircraft velocity in north-south and east-west directions.

4–117. The V_x pulse train is applied to the V_x binary multiplier; the V_y pulse train is applied to the V_y binary multiplier. Both multipliers have two sets of output windings. One set is gated by the sine of the heading angle θ_h and the other by the cosine of the heading angle (0° = north, first quadrant = northeast). Four outputs are thus obtained: V_x sin. θ_h; V_x cos θ_h; V_y sin. θ_h; V_y cos θ_h.

4–118. The sine and cosine gates for the two heading multipliers are obtained from the heading converter and decoder, which are located in the Present Position Computer. The heading converter is servo-driven. (The heading angle signal for this servo comes from the aircraft

Compass System via the Course Computer where it will undergo correction for magnetic variation if the system is in the MAG mode of operation.)

4–119. The heading decoder functions in conjunction with the heading converter to produce a set of gating potentials that represent the binary encoding of the sine and also the cosine of the heading angle (referred to north). The converter and decoder also generate potentials that indicate the quadrant in which the heading angle lies.

4–120. Pulse trains V_x sin. θ_h, V_x cos θ_h, V_y sin. θ_h, V_y cos θ_h are distributed by a magnetic core selection network to output lines $V_{n\text{-}s}+$, $V_{n\text{-}s}-$, $V_{e\text{-}w}+$, and $V_{e\text{-}w}-$, according to the polarities of V_x and V_y and the polarities of the sine and cosine of the heading angle. The general formulas are:

$$V_{n\text{-}s} = V_x \cos \theta_h - V_y \sin. \theta_h$$
$$V_{e\text{-}w} = V_x \sin. \theta_h + V_y \cos \theta_h$$

4–121. In the above formulas, north and east are positive. The sine is positive in the first (northeast) and second (southeast) quadrants, and the cosine is positive in the first (northeast) and fourth (northwest) quadrants. The formulas assume that, with increasing heading angle, the absolute value of the sine increases in the first and third quadrants and decreases in the second and fourth quadrants.

4–122. They also assume that the absolute value of the cosine decreases in the first and third quadrants and increases in the second and fourth. This is in accordance with the normal trigonometric distribution of the sine and cosine functions throughout 360°.

4–123. As a matter of efficient construction of the heading converter, the sine output is made to increase through each of the four quadrants and the cosine output is made to decrease through each of the four quadrants (i.e. each output repeats the first quadrant functions four times in 360°). To maintain the proper solution of the general formulas through the second and fourth quadrants, we must then interchange the sine and cosine functions when the heading angle lies in these quadrants. This, in the second and fourth quadrants the general formula becomes $V_{n\text{-}s} = V_x$ "sin." $\theta_h - V_y$ "cos" θ_h.

4–124. The quotation marks indicate that the term within them designates a particular output of the heading decoder and not the trigonometric function. In practice, the two V_x pulse trains (V_x "sin." θ_h and V_x "cos" θ_h) are interchanged giving the same result as switching the "sin" and "cos" converter outputs.

4–125. In addition, the polarities of the sine and cosine, as well as of V_x and V_y, must be ascertained to solve the formulas. The quadrant indication from the heading decoder effectively accounts for the sine and cosine polarities. The polarities of V_x and V_y are obtained from the V_x and V_y differential synchronizers. The polarities determined how the four pulse trains are distributed among the $V_{n\text{-}s}+$, $V_{n\text{-}s}-$, $V_{e\text{-}w}+$, and $V_{e\text{-}w}-$ outputs of the heading resolution. These four outputs go to the wind memory.

4–126. WIND MEMORY. The function of the wind memory is to provide a secondary source of ground speed during periods when the doppler return it too weak to operate any one of the three trackers, when it is necessary to maintain radar silence, or when the pitch or roll angle exceeds ±27-1/2°.

4–127. During periods of normal radar return and tracking, relays in the wind memory connect the $V_{n\text{-}s}+$, $V_{n\text{-}s}-$, $V_{e\text{-}w}+$, and $V_{e\text{-}w}-$ inputs from the heading resolution directly to wind memory. During this time the wind memory continuously calculates wind speed by subtracting air speed from ground speed. This computed wind speed is stored in two forward-backward counters. One forward-backward counter stores wind velocity north-south and the other stores wind velocity east-west. The wind memory circuit also adds this wind speed to air speed and thus makes computed ground speed continuously available at the wind memory relays.

4–128. If any one of the three trackers loses the doppler spectrum signal return, if the pitch or roll angle exceeds ±27-1/2°, or when the Operate Switch is turned to the SIL position, a memory relay is activated and causes the computed ground speed to become the velocity output of the Present Position Computer.

4–129. Air Speed is derived from the air speed pick-off potentiometer (part of the aircraft instrument system). The output of this potentiometer is a d-c voltage proportional to air speed. This voltage is supplied to the wind memory where it is converted to a pulse train whose rate is proportional to air speed. The wind memory air speed resolution resolves the air speed into its components in the two cardinal directions bounding the quadrant in which the heading angle lies. The air speed resolution is simular to the heading resolution except that it has only two terms to work with, the sine and cosine of the heading angle times air speed. The air speed resolution is gated with the same outputs from the heading decoder, as is the heading resolution. The resolved air speed outputs appear as velocities north or south and east or west (A_n or A_s, and A_e or A_w).

4–130. During normal operation, the wind speed is solved in the two identical wind loops: north-south and east-west. Each is a digital servo loop. The north-south

wind loop, for example, causes a binary encoding of wind, north or south, to be stored in the north-south forward-backward counter so that a pulse rate from a multiplier gated by the north-south forward-backward counter, when added to the smaller of the terms $V_{n-s}+ + A_s$ or $V_{n-s}- + A_n$, is sufficient to counterbalance the larger of the terms. Any unbalance in the added pulse rates is used to drive the north-south forward-backward counter to a binary encoding representing the balancing factor and, thus, the correct wind speed.

4–131. When the wind memory relays are energized, they disconnect the four velocity inputs from the wind memory outputs. Computed ground speed is supplied to the wind memory outputs. Computed ground speed $V_{n-s}+ = A_n + W_n$. Also $V_{n-s}- = A_s + W_s$; $V_{e-w}+ = A_e + W_e$; and $V_{e-w}- = A_w + W_w$.

4–132. When the Operate Switch is placed in the SIL position, the system is forced into wind memory operation.

4–133. Over smooth water (less than Beaufort 1) during SEA operation, the doppler return may at times be too weak to operate any of the three trackers or the trackers may lock onto a transmitted side lobe which may give a relatively strong signal return. When one of the trackers ceases to function, the system will switch automatically to the wind memory mode as indicated by illumination of the MEMORY lamp. When the trackers lock on a transmitted side lobe, as indicated by erratic ground-speed and drift-angle indications, the system must be switched to the wind memory mode by turning the Operate Switch to the SIL position.

4–134. The north-south velocity pulse train outputs from the wind memory are applied directly to the V_{n-s} final count-down as well as to the digital-to-analog converter. The east-west outputs from the wind memory are also applied to the digital-to-analog converter, but are modified by the secant latitude loop before being supplied to the V_{e-w} portion of the final count-down.

4–135. SECANT LATITUDE LOOP. The function of the secant latitude loop is to convert east-west velocity data into a pulse train signifying east-west motion of the aircraft in terms of minutes of longitude. This is accomplished by multiplying the east-west miles-per-hour rate of aircraft velocity by the secant of the aircraft's present position latitude; the result being an east-west rate in angular minutes of longitude. This conversion is necessary in the information supplied to the Course Computer which solves and presents solutions in terms of latitude and longitude.

4–136. One north-south nautical mile is equivalent to one minute of latitude at any point on the earth's surface. All latitude lines are parallel and equidistant from one another. Therefore, conversion of a north-south miles-per-hour rate of aircraft velocity (V_n and V_s) into a north-south rate in angular minutes of latitude needs no correctional factor for aircraft position on the earth's surface.

4–137. One east-west nautical mile is equivalent to one minute of longitude at the equator only. All longitude lines converge at the poles. Therefore, one east-west nautical mile is equivalent to greater angles of longitude as the aircraft's position departs from the equator. At 75.5° latitude, one east-west nautical mile is equivalent to four minutes of longitude.

4–138. The east-west velocity is multiplied by the secant of latitude in a sec lat multiplier and then applied out to the final count-down circuits. The sec lat factor is set into the multiplier by a forward-backward counter. The counter is maintained at the secant of PP latitude in the following manner: the output ($V_{e-w} \times$ sec lat) is sent through a second multiplier where it is multiplied by cos lat PP. The secant is the reciprocal of the cosine so the cos lat PP multiplier will nullify the effect of the sec lat multiplier and the output will be just the east-west velocity. This output is compared to the east-west velocity input to the sec lat section from the wind memory section. If the two match, the count set into the forward-backward counter is truly the secant of latitude. This is so because the secant of latitude is the only factor that can be multiplied by $V_{e-w} \times$ cos lat and produce a result of V_{e-w}. If the two do not match, then this indicates an incorrect value of sec lat in the forward-backward counter. The difference will reset the counter to the correct secant value. When the latitude changes, a new value of cos lat PP is set into the cos lat multiplier. This will result in an input to the forward-backward counter, resetting it to the secant of the new latitude angle.

4–139. Secant latitude goes from one to infinity as latitude goes from 0° to 90°. A binary multiplier of the type used in the Present Position Computer cannot multiply by a factor greater than one. Modifications are made in the sec lat digital servo loop to enable it effectively to handle the required factors. First computations are restricted to latitudes of less than 75.5°, limiting secant latitude to four; and second, the secant latitude loop performs a portion (factor of 8) of the total pulse weighting count-down accomplished by the Present Position Computer. The secant latitude multiplier is so contructed that when secant latitude equals four, the multiplier is actually passing all of its input pulses, i.e., is multiplying by unity. Thus, it effects a count-down of four. The secant latitude circuits also incorporate an additional count-down by a factor of two. The final count-down circuits compensate for this count-down by

eight, accorded to V_{e-w} by the secant latitude loop, by counting down V_{n-s} eight times as much as V_{e-w} sec lat.

4–140. The sine latitude and cosine latitude for the secant loop are obtained from the latitude converter and decoder. The output of the Present Position Computer positions shafts in the Course Computer, continually representing the present position of the aircraft in terms of latitude and longitude. The present position latitude shaft, among other functions, turns the shaft of the latitude converter. The latitude converter is similar to the heading converter and provides a binary encoding of the sine and cosine of the present position latitude to nine binary places. The output of the latitude converter is transformed into gating potentials by the latitude decoder, located in the Present Position Computer.

4–141. For the same requirements of direction of increasing and decreasing sine and cosine functions as in the heading resolution, the sine gates must be substituted for cosine gates, and vice versa, in the second quadrant (southern hemisphere). This is accomplished by arranging the latitude decoder quadrant selection to reverse the two outputs of the cos (sin.) lat multiplier in the second quadrant. Thus, true cosine multiplications are obtained in the northern and southern hemispheres.

4–142. The output of the secant multiplier is supplied to the east-west portion of the final count-down.

4–143. FINAL COUNT-DOWN. Final count-down consists of two forward-backward counters. The north-south forward-backward counter converts pulses representing velocity north or south into a pulse train in which each pulse signifies 0.4 minute of latitude moved. The east-west forward-backward counter converts pulses representing velocity east or west multiplied by the secant of latitude factor into a pulse train in which each pulse signifies 0.4 minute of longitude moved.

4–144. The north-south count-down is performed by a 12-digit forward-backward binary counter, and the east-west count-down is performed by a 9-digit forward-backward binary counter. Thus the north-south count-down is a factor of 4096, and the east-west count-down a factor of 512. The difference in count-down, a factor of 8, has already been given to the east-west pulses in the secant latitude loop, as described above.

4–145. The input to the east-west forward-backward counter is a pulse train and its attendant polarity, both coming from the secant latitude loop. The input to the north-south forward-backward counter is on two pulse lines, each of which may contain pulses. The line containing the more pulses signifies, by its predominance, the direction of aircraft motion (north or south). The north-south forward-backward counter performs a differencing operation upon its dual-line pulse input. The east-west (longitude) and north-south (latitude) outputs of final count-down are each on two lines. Pulses are all on one line or the other, the particular line selected signifying the direction of aircraft motion. The outputs of the final count-down are sent to the fix storage.

4–146. FIX STORAGE. During flight it may be desirable to correct the present position coordinates by reference to a check point using the manual fix procedure. When the prerequisite procedure for obtaining a fix is completed, the Operate Switch is turned to the FIX position. While the system is in a fix condition, pulses from the final count-down, representing changes in present position latitude and longitude, are stored in an 8-place binary counter (counter capacity is 102 minutes of latitude or longitude) in the fix storage. After the present position correction is made, the system is returned to normal operation. The pulses from the final count-down then are passed through fix storage, actuating the longitude and latitude stepper motors in the Course Computer. In addition, the pulses stored in the fix storage during the fix procedure also actuate the stepper motors, compensating for the change in present position that occured while the present position was being corrected. The stored pulses read out of fix storage at a rate of fourteen per second (when the system is returned to normal operation) until fix storage is exhausted.

4–147. As mentioned, the fix storage capacity is limited to 102 minutes of latitude and longitude. This is equal to 102 miles of latitude and 102 miles or less of longitude (less east-west distance per degree of longitude at higher latitudes). If fix storage capacity is exceeded, the stored information will be lost and another fix will be required. (See paragraph 1–35.)

4–148. DIGITAL-TO-ANALOG CONVERTER. The function of the digital-to-analog converter is to furnish two accurate 400-cycle a-c voltages that are proportional to the binary rates represented by the two pulse train inputs to the digital-to-analog converter. These pulse train inputs are north-south velocity and east-west velocity. These pulse trains are supplied from the heading resolution (via wind memory section) in the normal mode, and from the wind memory circuit in the memory mode. The analog a-c voltages representing north-south and east-west velocity are amplified and applied through polarity relays to the two electrical inputs of the ground track resolver located in the Course Computer. The ground track resolver is part of a servo loop that positions the ground track display on the Bearing Distance Heading Indicator.

4–149. The two inputs to the digital-to-analog converter are operated upon similarly. The north-south input, V_{n-s} is typical. This input is on two pulse lines, the correct value of the term being the difference in pulse rates between the two lines. This input is applid to a servo loop similar to the wind loops in the wind memory. The operation of the loop is such that a forward-backward counter gates a multiplier whose output is equal to the difference between the two pulse rates of the dual-line input. Polarity is also determined from the loop. The count in the forward-backward counter is regulated to represent the binary encoding of the difference between the dual-line input pulse rates. The forward-backward counter stages actuate relays and diodes in a precision analog ladder. The function of the ladder is to generate precise a-c potentials proportional to the forward-backward counter count. The output of the ladder is the V_{n-s} output of the digital-to-analog converter.

4–150. SYNCHRONIZATION. Throughout the Present Position Computer, pulse trains on separate lines are added together. Before addition, these trains must be synchronized so that they will not be time coincedent, thereby obscuring the addition. The high-frequency timing generator produces 6 pulse trains, each of 4500 cycles, and staggered so that pulses in no two trains coincide. The interval between a pulse in one train and the next pulse occuring in time in any other train is approximately 37 microseconds. These timing generator pulses are used to synchronize pulse trains throughout the Present Position Computer.

4–151. Data pulses can never occur at a faster average rate than timing pulses. But, since several pulse rates in different time slots are added at the roll-pitch resolution output, it is possible to have pulses bunched so that there is more than one pulse in the 222-microsecond period between successive pulses on a particular timing line. An ordinary synchronizer can accomodate only one data pulse in this period; therefore, a special type of synchronizer (differential) that can store pulses is used. The extra pulses are read out of storage at the synchronizer times when no pulses are coming into the differential synchronizer.

4–152. THEORY OF OPERATION OF COURSE COMPUTER AND INDICATORS.

4–153. GENERAL. The function of the Course Computer and indicators is to convert information received from the Present Position Computer, into the following displays: aircraft present position, ground track, ground speed, drift angle, course angle and distance-to-destination. The Course Computer also corrects magnetic heading data from the Aircraft Compass System. (See figure 4–3.)

4–154. The indicators associated with the Course Computer in performing these functions are: the Control Indicator, the Ground Speed Indicator, and the Bearing Distance Heading Indicator. Also included are ten servo amplifier and five resolver drive amplifiers which functionally belong with the Course Computer but physically are located in the Present Position Computer. The schematic diagrams, block diagrams and theory of operation in Section XI, treat the Course Computer and indicators in nine different sections according to function, as follows:

a. Lat PP: Receives Δ lat pulses from stepper drive output of Present Position Computer. Provides lat PP input to course angle-distance computation section and to magnetic variation correction section, and displays lat PP on LATITUDE counter. Also provides sin-cos lat PP for use in the sec lat loop in the Present Position Computer.

b. Long. PP: Receives Δ long. pulses from stepper drive output of Present Position Computer, Provides long. PP input to course angle-distance computation section and to magnetic variation correction section, and displays long. PP on LONGITUDE counter.

c. Lat dt: Drive by Latitude Slew Switch. Provides lat dt input to course angle-distance computation section and displays lat dt on LATITUDE counter.

d. Long. dt: Driven by Longitude Slew Switch. Provides long. dt input to course angle-distance computation section and displays long. dt on LONGITUDE counter.

e. Course Angle-Distance Computation: Receives lat PP, long. PP, lat dt and long. dt inputs from their respective sections. Computes course angle and the sine of distance-to-destination, and supplies them as inputs to the course indicator.

f. COURSE INDICATOR DRIVE: Receives course angle information from course angle-distance computation section and keeps course angle resolver at null. Converts sin dist into dist. Displays course angle and distance-to-destination on Course Indicator.

g. GROUND TRACK-GROUND SPEED-DRIFT ANGLE: Receives V_n-SV_e-^{w} and heading information from Present Position Computer. Drives ground track card on Course Indicator. Computes ground speed and drift angle, and displays them on Ground Speed Indicator.

h. Magnetic Variation Correction: Receives magnetic heading from Compass System. When Mode Switch is in MAG, compensates for magnetic variation and provides corrected magnetic heading to Present Position Computer.

4–155. The main section of those listed above is the course angle-distance computation section. The other sections serve mainly to provide the inputs or to display the outputs of the course angle-distance computation section. The Course Computer is set up to record two destinations (dt A and dt B). The course angle and distance-to-destination are computed relative to one of the destinations, but at any time the alternate destination can be switched in and the Course Indicator will then display the course angle and distance to the other destination.

4–156. Some illustrations and a simplified block diagram have been grouped together in figure 4–6 to aid in illustrating the basic problem solved by the course angle-distance computation section. All provisions for the dual destination features have been eliminated from this diagram to simplify it and to keep the emphasis on the operations involved. In figure 4–6A, the aircraft is shown at its present postion, and the destination is marked with an X. The known information is lat PP, long. P, lat dt and long. dt. The problem solved by the course angle-distance computation section is the determination of the course angle and distance-to-destination.

4–157. LONG-RANGE OPERATION. Two modes of operation are used: long range (LR) and short range (SR). In long-range operation, the computation requires the use of spherical trigonometry because the earth's surface is curved. In order to compute course angle and distance-to-destination by means of spherical trigonometry, the north-south and east-west components of the distance-to-destination must be found. The north-south component is determined by two factors: one of these is LA, which is the difference between lat dt and lat PP; the other one is the LON correction. (LON is the angular difference between long. PP and long. dt.) The need for this correction can be seen from figure 4–6A. If the aircraft is at the tip of the LA vector arrow and then proceeds to fly due east, it would reach its destination via the lat dt meridian. The shorter, more desirable route would be via the dotted line, requiring flying in a northeasterly direction. This shows that a north-south factor still remains to be found. This factor actually corrects for the curvature of the LON segment. (LON segments are the sections of lat meridians bounded by the LON angle.) The amplitude of this correction is determined by the value of LON. The greater the value of LON, the greater the length of the LON correction vector.

4–158. The east-west component of the distance-to-destination now must be found. The east-west vector will always be a line from the destination perpendicular to the long. PP meridian. To obtain this value, it is required to know LON and lat dt.

Note

References will be made to the sine and cosine of various navigational angles throughout this discussion. The angles referred to, with the exception of course angle and LON, are central angles with vertices located at the center of the earth (see figure 4–6B).

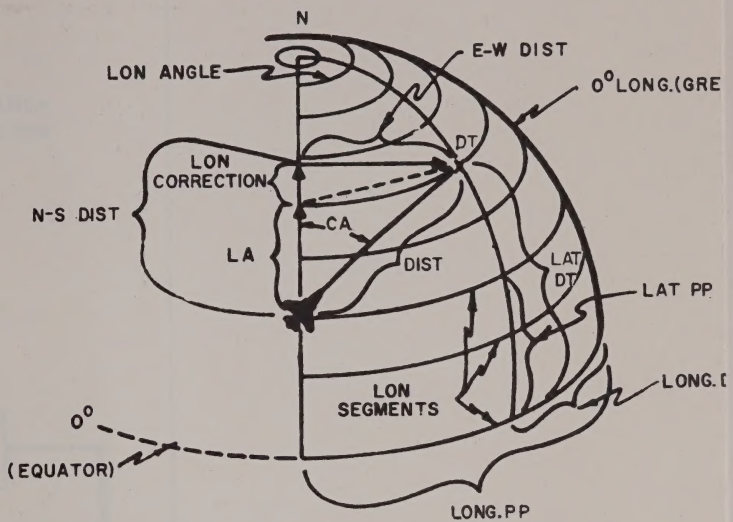
4–159. The north-south component is computed as follows: the lat dt sin.-cos resolver is driven by the lat dt gear train. The sin. lat dt output of this resolver is applied directly to the lat PP resolver while the cos lat dt output is sent to the LON resolver. Here the cos lat dt is multiplied by the cos LON. This factor increases the north-south distance according to the cos LON and this increase is represented by the LON correction vector in figure 4–6A.

4–160. It must be noted that LON is an angular expression, and the east-west distance corresponding to a value of LON depends on the lat. As lat increases, the actual length of a LON segment will decrease according to the cos lat. This decrease is caused by the convergence of the long. lines. By applying the cos lat dt to the LON resolver, we account for this decrease.

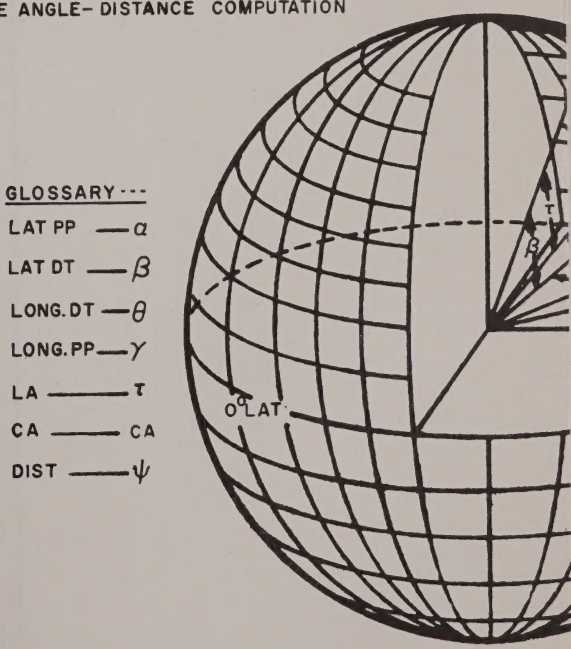
4–161. The cos lat dt $\times$ cos LON is applied from the LON resolver to the lat PP resolver, which is driven by the lat PP mechanical gear train. With lat dt and lat PP information present, the LA factor is accounted for and the lat P resolver output is the total north-south component of the distance-to-destination. The mathematical expression for this output is: sin. lat dt $\times$ cos lat PP — sin. lat PP $\times$ cos lat dt $\times$ cos LON. This expression is equivalent to cos CA $\times$ sin. dist.

4–162. A second output of the LON resolver is cos lat dt $\times$ sin. LON. This expression is equivalent to sin. CA $\times$ sin. dist, and represents the east-west component of the distance-to-destination corrected for both LON curvature and lat. The LON resolver is driven by the LON differential, which receives its input from the long. PP and the long. dt gear trains. The differential output is the difference between these two inputs.

4–163. The east-west and the north-south components are applied to the course angle resolver, and two outputs are developed. One of these is course angle error voltage. Any signal on this output line will operate a servo motor which will null the resolver via the course angle gear train. Therefore, course angle is represented by the resolver shaft angle while the course angle error voltage output it kept at a null by the servo mechanical feedback. The second course angle resolver output is the vector sum of the east-west and the north-south components of distance which is equal to the sin. dist. The sin. dist is easily converted into dist in the horizontal situation indicator drive section.



A. TRIGONOMETRIC QUANTITIES INVOLVED IN COURSE ANGLE- DISTANCE COMPUTATION



B. CENTRAL ANGLES USED IN ANGLE- DISTANCE COMPU

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4–155. The main section of those listed above is the course angle-distance computation section. The other sections serve mainly to provide the inputs or to display the outputs of the course angle-distance computation section. The Course Computer is set up to record two destinations (dt A and dt B). The course angle and distance-to-destination are computed relative to one of the destinations, but at any time the alternate destination can be switched in and the Course Indicator will then display the course angle and distance to the other destination.

4–156. Some illustrations and a simplified block diagram have been grouped together in figure 4–6 to aid in illustrating the basic problem solved by the course angle-distance computation section. All provisions for the dual destination features have been eliminated from this diagram to simplify it and to keep the emphasis on the operations involved. In figure 4–6A, the aircraft is shown at its present postion, and the destination is marked with an X. The known information is lat PP, long. P, lat dt and long. dt. The problem solved by the course angle-distance computation section is the determination of the course angle and distance-to-destination.

4–157. LONG-RANGE OPERATION. Two modes of operation are used: long range (LR) and short range (SR). In long-range operation, the computation requires the use of spherical trigonometry because the earth's surface is curved. In order to compute course angle and distance-to-destination by means of spherical trigonometry, the north-south and east-west components of the distance-to-destination must be found. The north-south component is determined by two factors: one of these is LA, which is the difference between lat dt and lat PP; the other one is the LON correction. (LON is the angular difference between long. PP and long. dt.) The need for this correction can be seen from figure 4–6A. If the aircraft is at the tip of the LA vector arrow and then proceeds to fly due east, it would reach its destination via the lat dt meridian. The shorter, more desirable route would be via the dotted line, requiring flying in a northeasterly direction. This shows that a north-south factor still remains to be found. This factor actually corrects for the curvature of the LON segment. (LON segments are the sections of lat meridians bounded by the LON angle.) The amplitude of this correction is determined by the value of LON. The greater the value of LON, the greater the length of the LON correction vector.

4–158. The east-west component of the distance-to-destination now must be found. The east-west vector will always be a line from the destination perpendicular to the long. PP meridian. To obtain this value, it is required to know LON and lat dt.

Note

References will be made to the sine and cosine of various navigational angles throughout this discussion. The angles referred to, with the exception of course angle and LON, are central angles with vertices located at the center of the earth (see figure 4–6B).

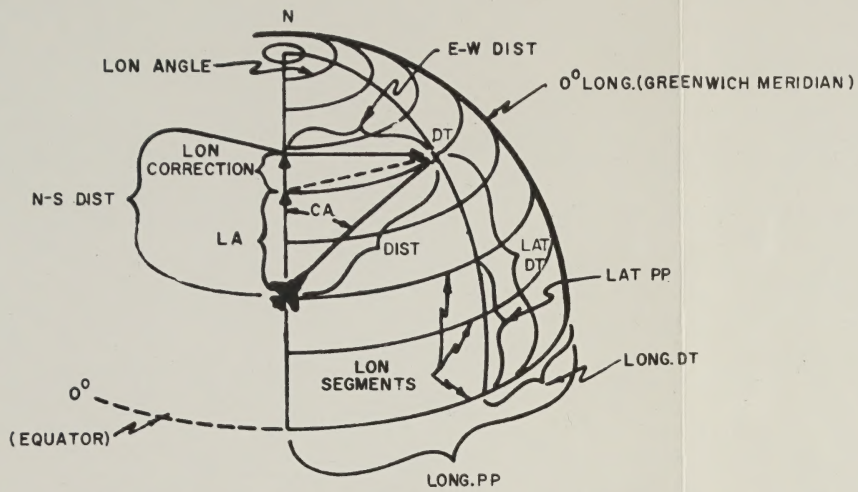
4–159. The north-south component is computed as follows: the lat dt sin.-cos resolver is driven by the lat dt gear train. The sin. lat dt output of this resolver is applied directly to the lat PP resolver while the cos lat dt output is sent to the LON resolver. Here the cos lat dt is multiplied by the cos LON. This factor increases the north-south distance according to the cos LON and this increase is represented by the LON correction vector in figure 4–6A.

4–160. It must be noted that LON is an angular expression, and the east-west distance corresponding to a value of LON depends on the lat. As lat increases, the actual length of a LON segment will decrease according to the cos lat. This decrease is caused by the convergence of the long. lines. By applying the cos lat dt to the LON resolver, we account for this decrease.

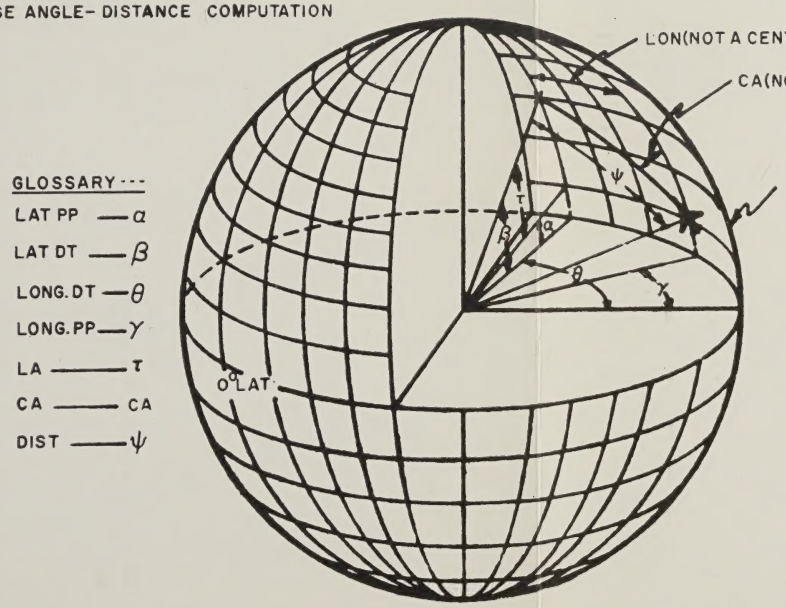
4–161. The cos lat dt $\times$ cos LON is applied from the LON resolver to the lat PP resolver, which is driven by the lat PP mechanical gear train. With lat dt and lat PP information present, the LA factor is accounted for and the lat P resolver output is the total north-south component of the distance-to-destination. The mathematical expression for this output is: sin. lat dt $\times$ cos lat PP — sin. lat PP $\times$ cos lat dt $\times$ cos LON. This expression is equivalent to cos CA $\times$ sin. dist.

4–162. A second output of the LON resolver is cos lat dt $\times$ sin. LON. This expression is equivalent to sin. CA $\times$ sin. dist, and represents the east-west component of the distance-to-destination corrected for both LON curvature and lat. The LON resolver is driven by the LON differential, which receives its input from the long. PP and the long. dt gear trains. The differential output is the difference between these two inputs.

4–163. The east-west and the north-south components are applied to the course angle resolver, and two outputs are developed. One of these is course angle error voltage. Any signal on this output line will operate a servo motor which will null the resolver via the course angle gear train. Therefore, course angle is represented by the resolver shaft angle while the course angle error voltage output it kept at a null by the servo mechanical feedback. The second course angle resolver output is the vector sum of the east-west and the north-south components of distance which is equal to the sin. dist. The sin. dist is easily converted into dist in the horizontal situation indicator drive section.



A. TRIGONOMETRIC QUANTITIES INVOLVED IN COURSE ANGLE- DISTANCE COMPUTATION



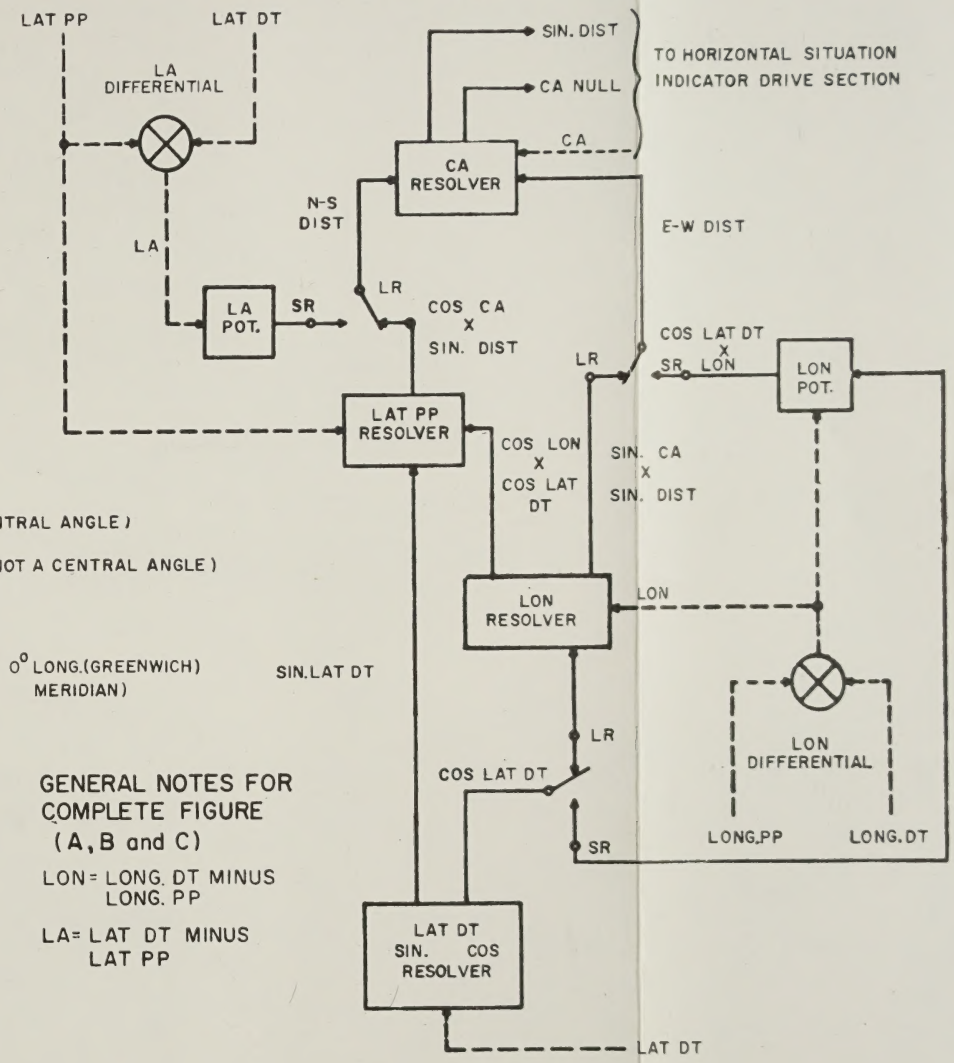
GLOSSARY---
LAT PP — α
LAT DT — β
LONG.DT — θ
LONG.PP — γ
LA — τ
CA — CA
DIST — ψ

B. CENTRAL ANGLES USED IN COURSE ANGLE- DISTANCE COMPUTATION

GENERAL NOTES FOR COMPLETE FIGURE (A, B and C)

LON = LONG. DT MINUS LONG. PP

LA = LAT DT MINUS LAT PP



C. SIMPLIFIED BLOCK DIAGRAM OF COURSE ANGLE-DISTANCE COMPUTATION

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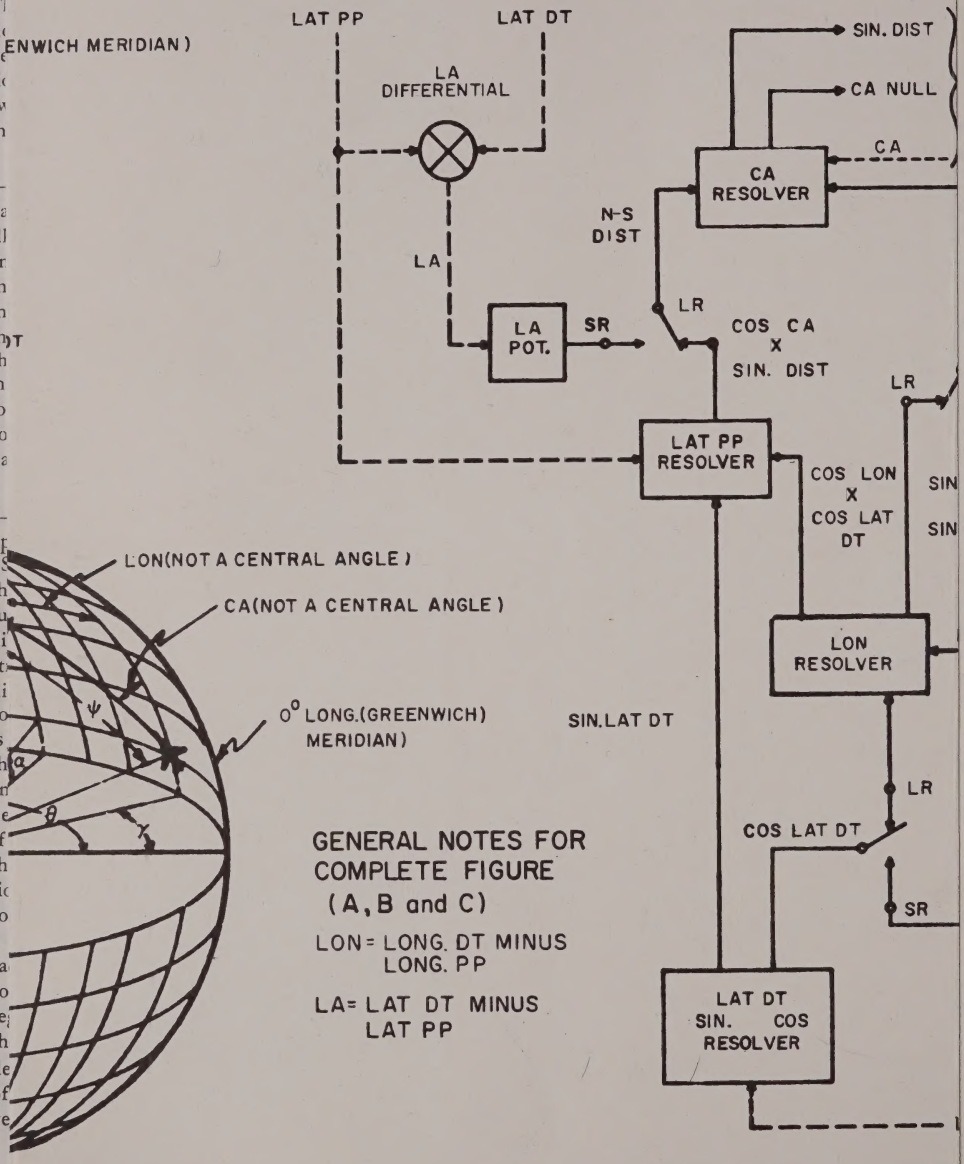
Figure 4-6. Geometry Associated with Course Computation



C. SIMPLIFIED BLOCK DIAGRAM OF CO
ANGLE–DISTANCE COMPUTATION

l COURSE
ITATION

Figure 4–6. Geometry Associated

4–164. SHORT-RANGE OPERATION. When the flight plan is over a relatively short distance, the course angle-distance computation section automatically goes into short-range operation. In short range, the section of earth involved in the computation is so small that it can be considered a flat plane with a satisfactory degree of accuracy. The problem now loses its spherical nature and becomes one in plane trigonometry. It follows from this that the triangle shown in figure 4–6A will then have straight sides and will become flat.

4–165. Because the value of LON is small, the east-west vector now lies along the lat meridian. The east-west distance is not great enough to require any LON curvature correction, therefore the north-south component is comprised entirely of LA. The value of LA is small enough to ignore the north-south curvature of the earth, so a linear output from a potentiometer can be used to supply the LA information. This is the LA potentiometer. The LA mechanical input to the potentiometer is developed in a manner similar to the development of the LON resolver mechanical input. Lat dt and lat PP mechanically feed into the LA differential, and the difference output of the differential drives the LA potentiometer.

4–166. As mentioned before, the east-west distance is treated as a straight line; therefore, a linear LON potentiometer can be utilized to supply the east-west component. However, in order to provide this output, the LON potentiometer must still be corrected for lat. The actual length of a LON segment is determined by the latitude at which the segment is taken. To correct for this, the LON potentiometer is excited by the cos lat dt output of the lat dt resolver. The output of the LON potentiometer is then cos lat dt $\times$ LON.

4–167. In short-range operation, the following approximations are made:

a. LA (SR) $=$ cos CA $\times$ sin. dist (LR) (n-s distance component).

b. Cos lat dt $\times$ LON (SR) $=$ sin. CA $\times$ sin. dist (LR) (e-w distance component).

4–168. THEORY OF OPERATION OF POWER SUPPLY 60504.

4–169. GENERAL. The function of the Power Supply is to provide both regulated and unregulated a-c and d-c voltages that are required to operate Radar Set AN/APN-105. The Power Supply also provides protection against overvoltage and undervoltage from each regulated d-c supply and against undervoltage from the 400 cps primary a-c power. For component warmup and stabilization the Power Supply provides time delays prior to the application of the high voltages. The time delays also provide for gyro erection before the normal gyro power is applied. Serial numbers 6 through 45, the +22 V dc controls the zero degree phase and the +34 V dc controls the +120° phase. Serial numbers 46 and above, the +34 V dc controls the zero degree phase and the +22 V dc controls the +120° phase. The following discussion is related to serial numbers 46 and above.

4–170. The Power Supply is a completely transistorized unit utilizing conventional circuits which are universally employed. Physically, it consists of a transformer subassembly, an alarm and relay subassembly, and seven printed circuit cards. Functionally, the Power Supply consists of six sections: (1) primary a-c power, (2) saturable reactor control, (3) low voltage, (4) intermediate voltage, (5) high voltage, and (6) control and protection circuits.

4–171. PRIMARY A-C POWER. The primary a-c power section distributes three-phase, 400-cps, a-c power to the primaries of all power transformers within the Power Supply. These transformers in turn, supply a-c voltages to the Present Position Computer, the vertical gyro (in the Antenna Unit) and to all the d-c supplies within the Power Supply. This section consists of seven power transformers, and three saturable reactors.

4–172. Four power transformers feed all the d-c supply sources within the Power Supply. These four transformers provide the a-c voltages that are distributed to the printed circuit cards for rectification, filtering, and regulation. Each of these transformers is controlled by a saturable reactor. The saturable reactors provide for preregulation of the a-c voltages applied to the primaries of these transformers. The remaining three power transformers supply various a-c voltages at different phases to the Present Position Computer and to the vertical gyro.

4–173. SATURABLE REACTOR CONTROL. The saturable reactors used in the Power Supply consist of two windings. One winding (control winding) is connected to a saturable reactor control circuit which provides a variable d-c current through the winding; the other winding is connected in series with the primary of the transformer whose a-c input is to be controlled. The d-c current for the saturable reactor control winding is obtained from the aircraft +28 V d-c supply. The saturable reactor control circuit reference is obtained from a zener diode network. The input control signal is one of the d-c outputs derived from the particular phase being controlled. The d-c output used to control the saturable reactor is taken before it is applied to its own regulator. Since the sampled d-c voltage is unregulated, it varies at that phase of the three-phase input which provides that voltage. The saturable reactor control circuit amplifies these variations and, in turn, supplies the d-c control voltage to the controlled winding of the

saturable reactor to accomplish the preregulation of that particular phase.

4–174. Since the primary of the power transformer and the controlled winding of the saturable reactor are connected in series, the saturable reactor functions as a variable series impedence to control the level of ac applied to the transformer. The over-all result produced by the combination of the saturable reactor with the saturable reactor control circuit is regulation of the input to the four power transformers which supply the d-c outputs.

4–175. LOW-VOLTAGE SUPPLIES. The low-voltage section comprises two +6.3 V d-c unregulated supplies, a +18 V d-c regulated supply, a +22 V d-c regulated supply, a +34 V d-c regulated supply, a +44 V d-c regulated supply and a —44 V d-c —27 V d-c unregulated supply. The regulated supplies utilize conventional transformer-rectifier-filter-regulator circuitry; the unregulated supplies utilize conventional transformer-rectifier-filter circuitry. The transformers are of the full-wave, center-tapped type and are mounted on the transformer subassembly. The rectifiers comprise two solid-state semiconductors and are mounted on three printed circuit cards 6003, 6004, and 6005, together with their associated filter and regulator circuitry. The two +6.3 V d-c supplies are on card 6003, the +18 V d-c, +22 V d-c, and +34 V d-c supplies, on card 6004; and the +44 V d-c, —44 V d-c, —27 V d-c supplies, on card 6005.

4–176. The two +6.3 V d-c unregulated supplies furnish +6.3 V d-c to the Antenna Unit for klystron filament excitation. One supply is referenced to —500 V d-c and furnishes +6.3 V d-c at —500 volts to the filament of the klystron master oscillator and two of the three klystron amplifiers. The other supply is referenced to —750 V d-c and furnishes +6.3 V d-c at — 750 volts to the klystron final amplifier. The rectifier-filter circuit in both supplies is fed by the klystron filament transformer. The a-c input to the klystron filament transformer is preregulated by the —120°-phase saturable reactor which uses the unregulated +44 V d-c supply as an input control signal. A potentiometer located on the front panel of the Power Supply provides for narrow adjustment of the 6.3 V d-c output.

4–177. The +22 V d-c supply furnishes a regulated +22 V d-c output for the Antenna Unit and Present Position Computer. It also provides +22 V d-c as the signal control voltage for the +22 V d-c saturable reactor control circuit and a regulated +22 V d-c to the +18 V d-c regulator. The rectifier-filter-regulator circuit is fed by the +120°-phase power transformer. The a-c input to the +120°-phase power transformer is preregulated by the +120°-phase saturable reactor. The filter is a two-section choke-input, capacitor-output device. The +22 V d-c for the saturable reactor control circuit is taken directly from the filter output. A potentiometer provides for narrow voltage adjustment of the +22 V d-c regulated output.

4–178. The +18 V d-c regulator furnishes a +18 V d-c regulated output for the Present Position Computer. This output is developed from the +22 V d-c output by a dropping resistor and a shunt-voltage regulator.

4–179. The +34 V d-c supply furnishes a +34 V d-c regulated output for the Antenna Unit, Present Position Computer, and Modulator Unit. It also supplies +34 V d-c to the +34 V d-c saturable reactor control circuit. The +34 V d-c rectifier-filter-regulator circuit is similar to the +22 V d-c rectifier-filter-regulator network, except that it is fed by the 0°-phase power transformer. The a-c input to the 0°-phase power transformer is preregulated by the 0°-phase saturable reactor. The +34 V d-c output of the filter serves as a signal control voltage for the +34 V d-c saturable reactor control circuit. Narrow voltage adjustment of the +34 V d-c regulated output is provided by a potentiometer.

4–180. The +44 V d-c supply furnishes a +44 V d-c regulated output for the Present Position Computer, Antenna Unit, and Modulator Unit. It also supplies +44 V d-c to the +44 V d-c saturable reactor control circuit. The +44 V d-c rectifier-filter-regulator circuit is fed by the —120°-phase power transformer. The a-c input to the —120°-phase power transformer is preregulated by the —120°-phase saturable reactor. The filter is a two-section choke-input, choke-output device. A potentiometer provides for narrow voltage adjustment of the shunt-regulated +44 V d-c output.

4–181. The —44 V d-c supply furnishes unregulated —44 V d-c and —27 V d-c outputs for the Present Position Computer. The —44 V d-c rectifier-filter network is fed by the +120°-phase power transformer. The a-c input to the +120°-phase power transformer is preregulated by the +120°-phase saturable reactor which uses the unregulated +22 V d-c supply as a signal control voltage. The filter is a two-section choke-input, capacitor-output device. The —27 V d-c output is taken from two zener diodes. The diode current is taken from the —44 supply.

4–182. INTERMEDIATE-VOLTAGE SUPPLIES. The intermediate-voltage outputs of the Power Supply are generated in separate supplies on cards 6001 and 6006, two supplies on each card. The intermediate-voltage outputs are +300 V d-c, +150 V d-c, —150 V d-c, and +125 V d-c. The +300 V d-c and the +150 V d-c supplies on card 6001; the other two are on card 6006. The —120°-phase power transformer feeds the +300 V d-c and the +150 V d-c outputs; the +120°-phase power transformer feeds the —150 V d-c and the +125 V d-c outputs. All four supplies are series regulated.

4–183. The circuits of these four supplies are similar. Each is fed by a separate transformer winding and consists of a full-wave, bridge-type rectifier and a single-section choke-input, capacitor-output filter. In addition, the output of each supply is regulated by an individual series regulator. A potentiometer in each supply provides narrow voltage adjustment of each regulated output. In portions of the intermediate-voltage supplies, zener diodes are used as clamps and to supply a constant reference voltage. Semiconductor diodes are used as power rectifiers, reverse-polarity surge protection devices and switches.

4–184. HIGH-VOLTAGE SUPPLIES. The high-voltage outputs are generated in a three-section power supply comprising a −500 V d-c section and two −250 V d-c sections. The three sections are connected in series to furnish an over-all output of −1000 V d-c, with taps at the −750 V d-c and −500 V d-c levels. The −500 V d-c source only is regulated by a series regulator.

4–185. The single transformer that supplies the high d-c voltages is located on the transformer subassembly; the bridge rectifier and filters, on card 6002; and the series voltage regulator for the −500 V d-c section, is on the 6007 card. The high-voltage supply circuit is conventional. Each section uses a separate secondary winding of the 0°-phase power transformer, a separate semiconductor-diode bridge rectifier, and a separate choke-and-capacitor filter.

4–186. The −500 V d-c section is more heavily filtered than the other two sections. Each rectifier in the bridge is shunted by a one-megohm resistor to equalize the load distribution across the rectifiers. A two-section choke-input filter is used, comprising two series chokes and shunt capacitors. The output circuit of the −500 V d-c supply also contains a dummy-load. Switching to the dummy load is accomplished by the radar silent relay when the Control Indicator Operate Switch is turned to SIL.

4–187. The center section of the high-voltage supply generates −250 V d-c in a manner similar to that of the −500 V d-c section, of the two-section choke-input, capacitor-output type. The third section of the high-voltage supply, uses a single-section choke-input, capacitor-output filter after the bridge rectifier.

4–188. CONTROL AND PROTECTION CIRCUITS. The basic circuits and detail parts required for control of Radar Set AN/APN-105 operation are contained in the Power Suply and the Control Indicator. Control of starting, stopping, and standby operation is provided by the manual Mode Switch and the Operate Switch on the Control Indicator. When the Mode Switch is turned to either the MAG or DG positions, all the a-c voltages and the 6.3 V d-c filament voltages are applied to the system. The alarm and relay subassembly of the Power Supply provides a one-minute time delay which retards application of all the d-c voltages to allow for filament warmup and stabilization. Another time delay allows three minutes for initial vertical gyro erection. Relays also provide interlock protection by interrupting all power whenever the cover, any front panel plugs, or any of the card subassemblies of the Power Supply are not in place.

4–189. The d-c overvoltage-undervoltage network located on card 6003 provides protection against abnormal outputs from various sections of the Power Supply. This network senses abnormal outputs from all d-c supplies within the Power Supply except the −1000 V d-c, −750 V d-c, −27 V d-c, and +22 V d-c outputs, and sends a +28 V d-c signal to the control circuits to shut down Radar Set AN/APN-105 before damage can result. In addition, an overload lamp DS6001 on the front panel of the Power Supply provides a visual alarm whenever an overload condition exists. Another subassembly, network Z60001, provides protection against low 400-cps line voltage.

SECTION V
DESCRIPTION OF SYSTEM TIE-IN OF EQUIPMENT AND ACCESSORIES

5–1. GENERAL.

5–2. This section describes aircraft electronic equipment and accessories only where tied into Radar Set AN/APN-105 and does not necessarily cover all functions of the aircraft equipment and accessories.

5–3. Radar Set AN/APN-105 is connected to the aircraft equipment as shown in Table 5–1.

5–4. INPUT POWER

5–5. Input power is supplied to the Power Supply from the aircraft. Input power requirements of Radar Set AN/APN-105 are given in paragraph 1–21.

5–6. COOLING AIR SUPPLY.

5–7. Cooling air is required by all units of Radar Set AN/APN-105 except the two indicator units, mounted in the cockpit, and the course computer. Cooling air requirements are given in paragraph 1–45.

5–8. ATMOSPHERIC PRESSURE.

5–9. Atmospheric pressure may be supplied through an aircraft line to the Modulator Unit. As the equipment is not pressurized, the atmospheric pressure available at the Modulator Unit may be used directly.

5–10. COURSE INDICATOR.

5–11. Course angle ground track and distance to destination are outputs of Radar Set AN/APN-105 that are displayed on the Course Indicator. These outputs are supplied to the Course Indicator through a junction box which has provisions for selecting alternate outputs from some other aircraft equipment for display on the Course Indicator. The course, ground track and distance-to-destination displays from Radar Set AN/APN-105 are so integral a part of system operation that the methods of presentation are discussed fully where relevant in Section XI together with complete diagram presentation.

5–12. AIR DATA COMPUTER.

5–13. The air data computer furnishes air speed information to Radar Set AN/APN-105. The shaft of a 1000-ohm potentiometer in the air data computer is driven by the aircraft air speed measuring device. The calibration of the potentiometer is linear from 0 to 1500 knots air speed. Mounted with the potentiometer is a limit switch that closes when the potentiometer is set to positions representing less than 104 knots air speed or to the positions representing 1500 knots or above. The potentiometer and limit switch are connected to J1306 of the Present Position Computer via the aircraft harness. Pins

Table 5–1. Aircraft Connections To Radar Set AN/APN-105

Aircraft Connection	Purpose	Connects to
Primary power 115 v ac 3 ϕ, 26 v ac, +28 v dc	Supplies primary power to Radar Set AN/APN-105	J6001 (Power Supply 60504)
Cooling air supply	Supplies required cooling for units	Units, through plenum chamber
Atmospheric pressure	Operates Baroswitch S201	Inlet on Frequency Converter-Transmitter 58002 (Modulator Unit)
Indicator, Bearing-Distance-Heading ID-416/ARN or Collins Radio type 331C-4A (Course Indicator)	Displays course, ground track and distance-to-destination	J5005 (Computer, Navigational 51868) (Course Computers) through navigation mode selector relay box
Computer, Central Air Data, Type MG-1 (air data computer)	Furnishes air speed information to Radar Set AN/APN-105	J1306 (Computer, Navigational 60301) (Present Position Computer)
Aircraft Compass System	Furnishes heading information to Radar Set AN/APN-105	J5006 (Course Computer)

B and C of J1306 are shorted together by the potentiometer at 0 knots air speed, and have 1000-ohms resistance between them at 1500 knots. The limit switch furnishes +44 v dc to J1306-E when the limit contacts are closed.

5–14. The limit switch provides +44V d-c to J1306-E when the limit switch contacts are closed. The +44V d-c disables the wind memory circuit in the Present Position Computer. The operational upper limit of the Air Data Computer is 1500 knots. The low velocity cutoff prevents air speed inputs during ground tests.

5–15. AIRCRAFT COMPASS SYSTEM. (Refer to table 1–1 for display definition.)

5–16. GENERAL. The Aircraft Compass System (Gyro Compass) connects to J5006 of the Course Computer through the aircraft interlock relay. The Gyro Compass provides heading information in the form of three-wire synchro signals. There are two possible modes of Gyro Compass operation: magnetic (MAG) and directional gyro (DG).

5–17. MAGNETIC MODE. The MAG mode is used in normal operation (below 75° latitude). In this mode, the Gyro Compass is aligned with and slaved to the magnetic azimuth detector (flux valve) for northward orientation. The gyro stability smooths out sudden compass fluctuations, which may be caused by aircraft maneuvers, so that only the average direction of the earth's magnetic field is indicated by the gyro.

5–18. In the MAG mode a heading correction is required to compensate for the angular difference (variation angle) between magnetic north and true north. The Gyro Compass heading output signal is applied to the stator of a magnetic differential transformer in the Course Computer. The rotor position is determined by a cam follower, which in turn is positioned by the lat PP and long. PP gear trains. In this manner, the heading information is compensated for the magnetic variation at any point on the earth's surface at latitudes less than 75°N and 75°S. The heading, corrected to true north, is supplied from the differential rotor through the closed contacts of a magnetic correction relay (energized in the MAG mode) to the Present Position Computer through J5036 and J1364.

5–19. DG MODE. The DG mode is usually used above 75° latitude (polar operation) where the horizontal component of the earth's magnetic field becomes too weak for accurate magnetic compass operation. In this mode, the magnetic flux valve is not used and the compass becomes a free gyro. With no slaving to orient the Gyro Compass, it must initially be oriented by slewing the gyro. Orientation in polar operation requires the use of transverse coordinates. (See figure 4–2.) In this coordinate system, the artificial north pole is located at the equator and the earth's 90° longitude meridian becomes the transverse equator. All latitude and longitude information throughout the complete system is then referred to transverse coordinates in polar operation. In this manner, the unslaved gyro provides the heading reference.

5–20. Magnetic variation correction is not used in this mode of operation because the Gyro Compass is free and not using magnetic slaving. With the Gyro Compass free, there will be a slight drift error that will gradually build up over a period of time; therefore the DG mode is not usually employed below 75° latitude as most long range flights are planned within these lower latitudes.

5–21. AVAILABLE OUTPUTS.

5–22. Table 5–2 lists connectors and outputs of Radar Set AN/APN-105 which may be employed by auxiliary equipment if desired.

Table 5–2. Radar Set AN/APN-105 Connectors And Outputs For Auxiliary Equipment

Unit	Case Connector	Function
Present Position Computer	J1314:	
	Connector Pin	
	1	V_x
	2	V_y
	3	pol V_x
	4	pol V_x
	5	pol V_y
	6	pol V_y
	7	$+V_z$

Table 5–2. Radar Set AN/APN-105 Connectors And Outputs For Auxiliary Equipment (Cont)

Unit	Case Connector	Function
Present Position Computer (cont)	J1314 (cont):	
	Connector Pin	
	8	$-V_z$
	9	$W_{e\text{-}w}$
	10	$W_{n\text{-}s}$
	11	pol $W_{e\text{-}w}$
	12	pol $W_{e\text{-}w}$
	13	pol $W_{n\text{-}s}$
	14	pol $W_{n\text{-}s}$
	15	memory = +28 v dc
	16	not used
	17	not used
	18	not used
	19	not used
	20	heading S1
	21	heading S2
	22	heading S3
	23	not used
	24	not used
	25	not used
	26	$V_{n\text{-}s}$ (1)
	27	$V_{n\text{-}s}$ (2)
	28	ground speed hi
	29	d-c sig gnd
	30	pitch sta comm
	31	pitch sta yel
	32	pitch sta blu
	33	roll sta comm
	34	roll sta yel
	35	roll sta blu
	36	a-c ground
	37	26 v ac $\underline{/-90°}$
	38	26 v ac $\underline{/-90°}$
	39-50	not used
Course Computer	J5001:	
	Connector Pin	
	1	fine lat pp S3
	2	fine lat pp S1
	3	coarse lat pp S3
	4	coarse lat pp S1
	5	synchro common
	6	coarse long pp S3
	7	coarse long pp S1
	8	fine long pp S1
	9	fine long pp S3

Table 5–2. Radar Set AN/APN-105 Connectors And Outputs For Auxiliary Equipment (Cont)

Unit	Case Connector	Function
Coarse Computer (cont)	J5002:	
	Connector Pin	
	4	aux CA R1
	5	spare
	6	aux GT S3
	7	aux GT S2
	8	aux GT S1
	9	aux GT R2
	10	aux GT R1
	18	aux CA S3
	19	aux CA S2
	20	aux CA S1
	28	aux CA R2
Course Computer (to navigation mode selector relay box)	J5005:	
	Connector Pin	
	h	delayed +28 v dc
Course Computer (auxiliary output)	J5008:	
	Connector Pin	
	A	dist 1 S1
	B	dist 1 S3
	C	dist 10 S1
	D	dist 10 S3
	E	dist 100 S1
	F	dist 100 S3
	H	drift angle R1
	J	CA S1
	K	CA S2
	L	CA S3
	M	d-c ground
	N	+28 v dc 0 to 1000 mi
	P	dist com-S2
	R	drift angle R2
	S	GT S2
	T	26 v ac ex lo
	U	26 v ac ex hi
	V	drift angle R3
	W	GT S3
	X	GT S1